ILLUMINATING ENGINEERING

NOVEMBER 1953

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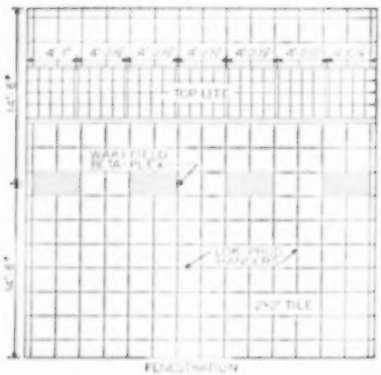
Efficiency and Appearance of Luminous Panels
Interflectance Tables from Photometric Data
Winners — National Lighting Job Contest
Characteristics of Lamps and Ballasts
Direct Lighting in Schools
Cold Cathode Ballasts

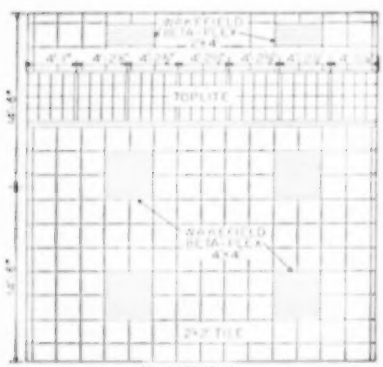
THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

How to supplement glass block skylighting by using Wakefield Beta-Plex units



FENESTRATION

For daytime only: *four 2′ x 4′ Beta-Plex recessed units are mounted on the ceiling almost in the center of the room. The arrangement of side wall and glass block skylighting shown here will put the low point of daylight directly under the Beta-Plex units.*



FENESTRATION

For Day and Night Use: *a minimum of 30 ft-C of electric light to meet the requirements of American Standard Practice will be provided by this arrangement of two 2′ x 4′ and four 4′ x 4′ Beta-Plex units. Separate circuits and switches will permit full (night) or partial (day) use.*

Wakefield Beta-Plex **is a complete unit ready for recess mounting in a suspended ceiling. Separate circuits and switches may be installed for different lighting levels. The ballasts and lamp-holders are contained in an individual metal housing that provides for hook-on suspension points for the Wakefield Rigid-Arch Diffuser.**

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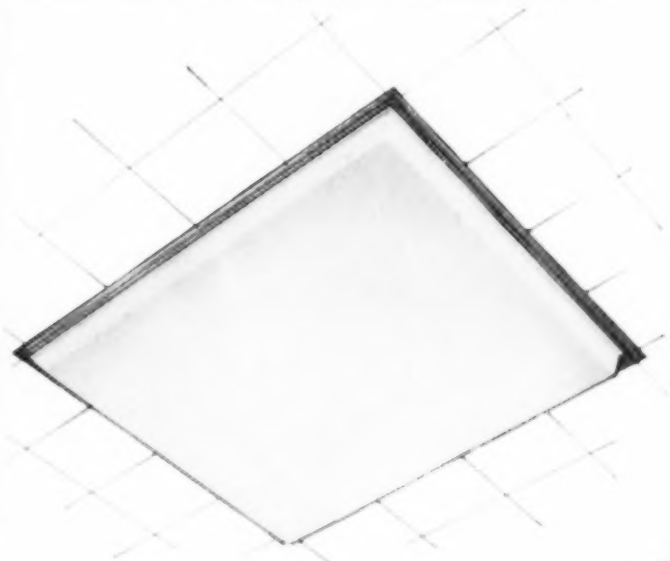
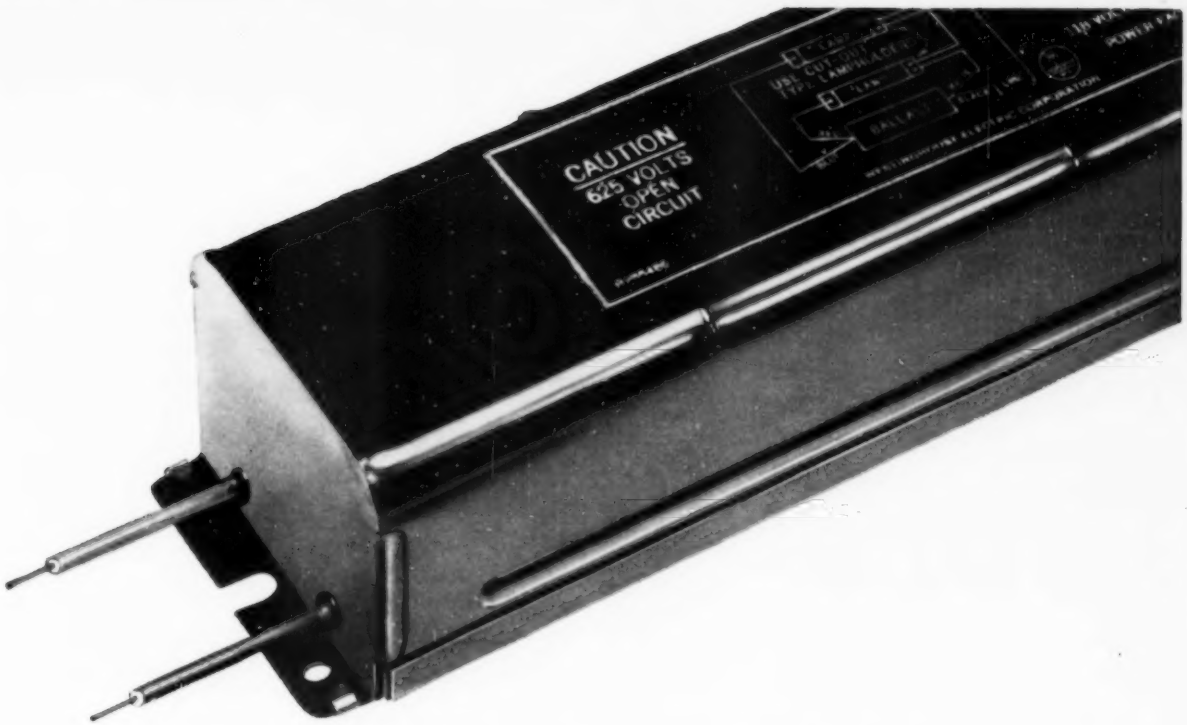
For an illustrated, descriptive 8-page folder on Beta-Plex, write to The F. W. Wakefield Brass Company, Vermilion, Ohio. In Canada: Wakefield Lighting Limited, London, Ontario.



WAKEFIELD GEOMETRICS

Integrated modular components for functional ceilings

Beta-Plex is one of a series of Wakefield Geometrics. Others are Omega-Plex, Theta-Plex and Sigma-Plex. Folders describing each are available.



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Once upon a time, ballast manufacturers considered *lead-lag* slimline ballasts as impractical to push because of weight, cost and size. *Westinghouse has changed all that.* New design and engineering have made weight, cost and size *comparable* to series ballasts. These new Westinghouse engineering advances, plus the manifold advantages always inherent in *lead-lag,* make its choice by users of fluorescent lighting a matter of common sense and sound economics. Here's why:

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(State Savings Bank, Hartford, Conn.)

For plenty of light that's easy on eyes, these LITECONTROL 5938 recessed fixtures give 60 foot-candles initial average intensity. Yet there's very little brightness any way you look. LITECONTROL encourages a pleasant atmosphere that attracts customers, is nice to work in.

(Hartford Connecticut Trust Company, Hartford, Conn.)

To keep busy eyes sharp all day, LITECONTROL 5128 2-lamp recessed slimline fixtures give 65 foot-candles average initial intensity. Holophane lenses prevent glare or harsh contrasts. Hinged doors with simple *snap-lock catches* open and close at a finger's touch.

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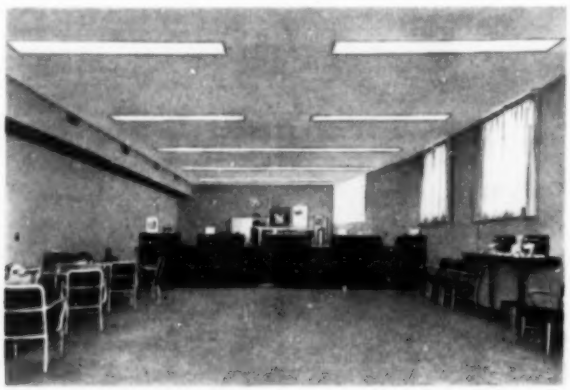

To give a clear, uncrowded look to this branch, despite its small size, LITECONTROL makes ease for eyes without desk lamps, glare or distracting shadows. Long fixtures give more light over the working area, short ones give the right light over the public. Easily maintained, very efficient.

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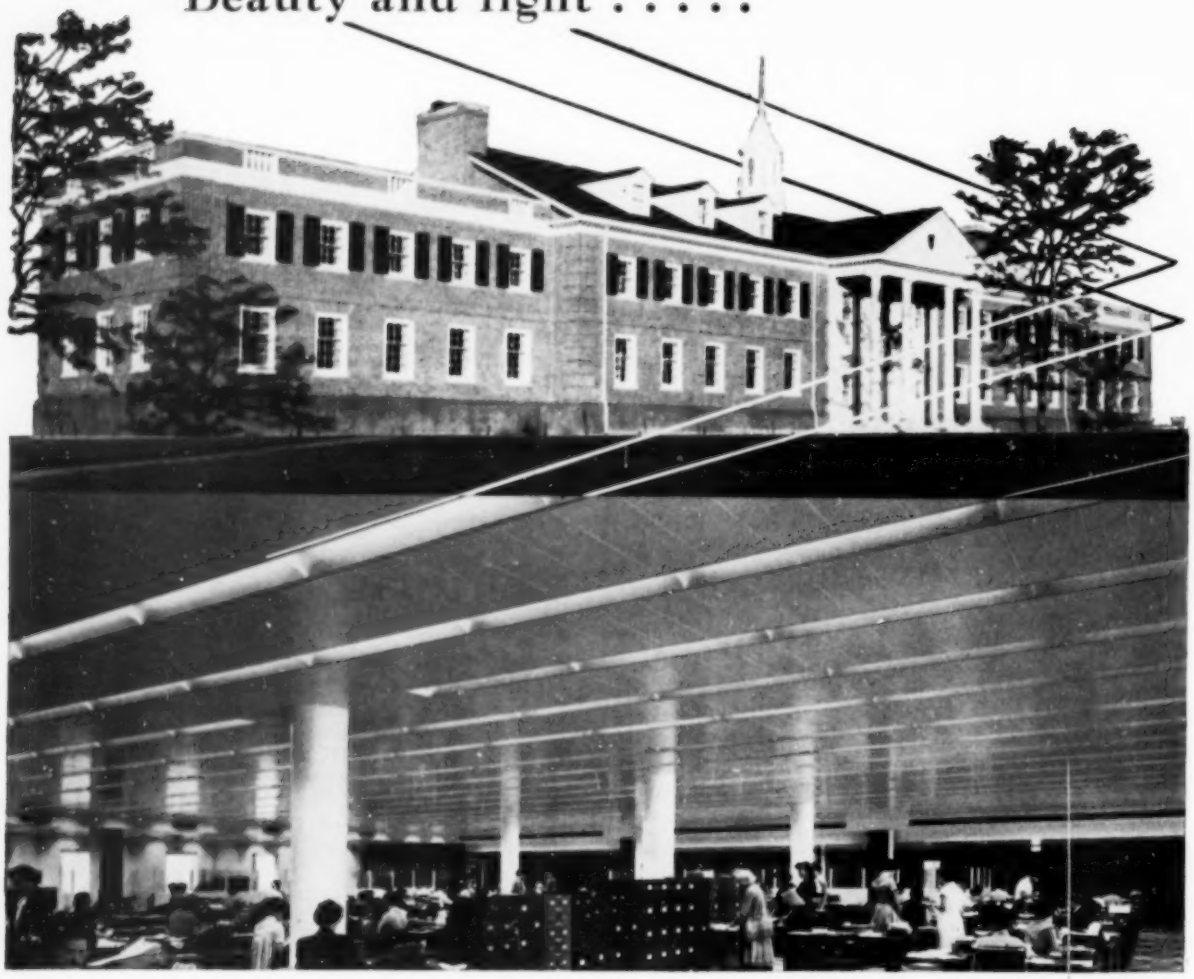
Beauty and light . . . . .



Architect—Victor L. Charn | General Contractor—Ragnar Benson Inc. | Electrical Contractor—Hultgren Electric Corporation

Colonial tradition in architecture and Curtis tradition in lighting

The new western headquarters of Aetna Insurance Company is situated in Suburban Park Ridge, Illinois; 25 miles from Chicago's "hum-drum" loop. This outstanding structure, on spacious landscaped grounds was designed to blend with the general motif of this progressive residential area and is an asset to the entire community.

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MERRILL R. HUMBER
Northern California Section, I.E.S.

First Prize — Lighting Broadway Tunnel

TWO BASIC engineering principles apply for the lighting of tunnels — as laid down by that "Bible" of lighting requirements, the *I.E.S. Lighting Handbook:*

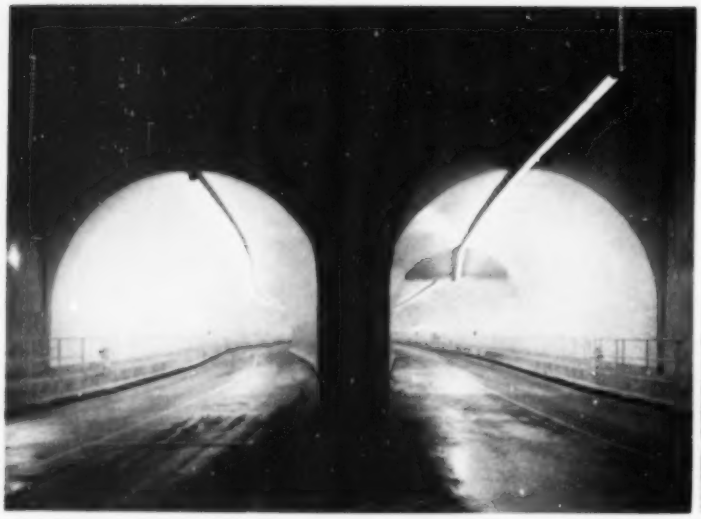
> a. Entrances should have supplementary lighting for daytime operation to avoid an abrupt change between the several thousand footcandles of daylight and the few footcandles in the tunnel. Such an abrupt change temporarily reduces the motorist's ability to see until his eye has been adapted.
> b. Illumination should be approximately 50 per cent greater than that recommended for the connecting street or highway or for a roadway carrying the same volume of traffic.

The prize-winning installation described, featured the successful application of these principles in the double-bore 1616-foot tunnel through Russian Hill, one of San Francisco's seven hills. Careful engineering of other factors, besides the basic lighting requirements, resulted in pleasing appearance, low cost (1.3 per cent of the total project) and visual comfort throughout the length of the tunnel. A practical study of brightness contrasts, illumination levels, color compatibility of lamps and walls, and the operating characteristics of lamps and ballasts has resulted in a noteworthy final design.

Each tube of the Broadway Tunnel contains two vehicular lanes and a pedestrian sidewalk, each bore handling one-way traffic only. The roadway

My Most Interesting Lighting Job

In competition with nine other Regional winners, this installation took first prize at the final contest for "My Most Interesting Lighting Job" held September 15, 1953 at the National Technical Conference of I.E.S. in New York City. This entry had previously won first place in the preliminary contests conducted by the Northern California Section and the South Pacific Coast Region of I.E.S. Mr. Humber is associated with the Humber & Walker Company, Manufacturers Representatives, San Francisco, California.



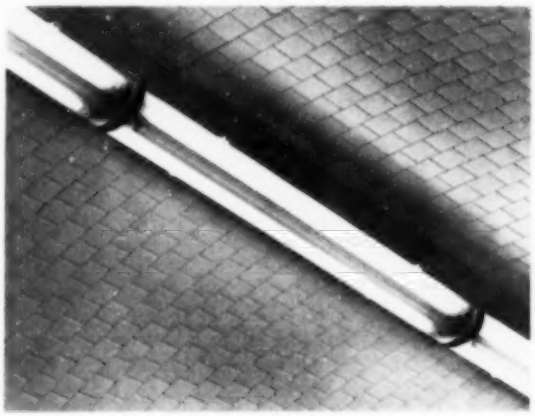
A glimpse into the twin-tubes of the Broadway Tunnel (left), showing the area covered by the glass block skylight immediately inside the portal.

Right — Some of the feeling of spaciousness created by the careful handling of brightness can be seen in this photograph of the tunnel proper.

is generally at a three per cent grade. Motorists are headed uphill on approaching from either direction and traveling downhill when leaving the tunnel. Thus the hill blocks high sky-brightness when approaching, and cross-overs eliminate glare when leaving. In addition, the roadways make a slight lateral curve. Each tube is approximately 23½ feet wide at the roadway with the crown of the tunnel 22 feet above the road surface. Tunnel walls are finished up to the eight-foot level with yellow glazed tile of about 60 per cent reflectance, while for the remainder a lighter yellow matte tile of 75 per cent reflectance is used for maximum diffusion.

Traffic surveys indicated an immediate density of 1400 vehicles per hour, and the planners, to provide for future traffic growth, designed the tunnel to accommodate 2400 vehicles per hour. As the recommended illumination level for this traffic density (about 2.8 footcandles) seemed inadequate, the lighting goal was set at eight footcandles minimum acceptable level on the roadway.

A continuous row of 75-inch luminaires housing six-foot slimline fluorescent lamps operating at 120 ma, mounted at the crown of the tunnel, provides the illumination in each tunnel. Each of the 503 units installed contains either two or three lamps and is covered with an acrylic plastic refractor. As a mounting base, adjustable hanger channel was embedded in the concrete as it was poured, and after removal of the forms, raceways with removable side panels for servicing were bolted to the hanger channel. Two straps welded into each 75-inch section of raceway support the luminaire



A close-up of the luminaires, showing the raceway with its hinged side panel and the acrylic plastic cover. Some idea of the brightness control can be gained from the clarity of detail in each portion of this photograph. The luminaire is set for night operation with the third lamp switched off.

proper. The fixtures are designed to withstand the spray of detergents from maintenance trucks, with compressible seals between units maintaining water-tightness throughout the continuous row.

Lighting Plan

For illumination purposes during daylight hours, each tunnel is divided into three sections: Entrance,, Middle and Exit. In the Entrance section, each luminaire contains two 72T8 lamps operating at 120 milliamperes and one 72T12 lamp operating at 430 milliamperes. Here, footcandles delivered

on the roadway measure 26.4 at the center of the tunnel and 21.3 at the curb near the wall.

The Middle section uses the basic unit of two 72T8 lamps on 120 ma, augmented by one 72T8 lamp operating at 200 milliamperes. This produces 22.2 footcandles at the center-line, 17.5 minimum.

In the Exit section, the basic unit only is used, producing 13.4 footcandles at the center with 10.1 at the curb.

Prior to sunset each evening, the third lamp in each unit of the Entrance and Middle sections is switched off as the city street lighting system comes on. Thus, after sundown, the center-line illumination in all sections of the tunnel is 13.4 footcandles. The third lamps are switched back on at sunrise.

In the daytime, the transition from outdoor illumination to that of the tunnel is smoothed by a 40-foot glass block skylight at each end of each tube. At night, the transition from the lower level of street lighting to the 13.4 footcandles of the tunnel is aided by additional semi-recessed lensed units spaced 15 feet apart in the underpasses at the tunnel approaches. Two double armed street lighting poles using four 10,000-lumen lamps, plus four single 10,000 lumen lamp units on the street above all contribute to a comfortable approach at night.

Brightness, Color, Watts

Brightness readings taken during the daytime to obtain maximum values disclose no ratios greater than seven to one, and the overall brightness of the tile creates a feeling of spaciousness not generally associated with tunnels. Part of this feeling may be due to the color of the lamps selected. Each of the two types of tile to be used was viewed in shadow box tests under many colors of fluorescent lamps. The designers concluded that the appearance of the tiles was most pleasing under lamps of 3500° white.

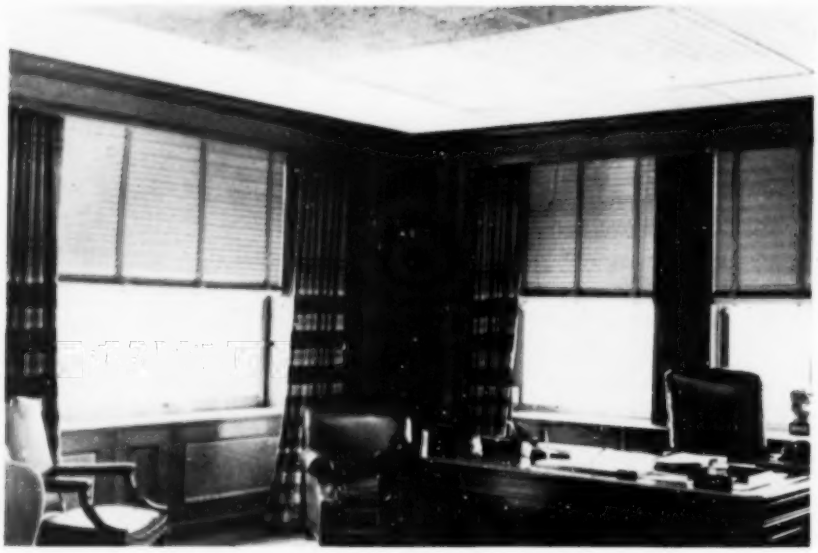
Series type fluorescent lamp ballasts were chosen because of their lower power loss. As over 1000 of the lamps in the installation will operate 24 hours per day, 365 days per year, it was calculated that the use of the series in preference to the lead-lag ballast would result in a saving of eight kilowatts, and in a year, 3,000 kilowatt-hours.

Others participating in the lighting of the Broadway Tunnel include: Ivan Sandberg, chief electrical engineer, city and county of San Francisco; Messrs. Kermit and Erdle, Morrison-Knudsen Company, Inc., general contractor; George F. Brayer and Werner Heintzen, George F. Brayer Company, electrical contractor; and the Sunbeam Lighting Company, Los Angeles, California.

Prize Award Presented at Conference

As first place winner in the national contest for "My Most Interesting Lighting Job," Merrill R. Humber, left, receives Certificate for First Award, and a check for $100.00. I.E.S. President Everett M. Strong, right, made the award before the assembled delegates of the National Technical Conference in New York City, September 17. Mr. Humber's winning installation, described on the preceding pages, represented the South Pacific Coast Region of I.E.S. in the final contest sponsored by the Lighting Service Forum.

SECOND



Integrated Functional Lighting Of an Executive Office

THE RATHER special requirements for an executive office, with two quite separate uses to be made of it, was the challenge which qualified this installation as a most interesting problem. Additional factors were the completely modern systems employed, top cooperation between architect, lighting engineer and electrical contractor, and final success of the solution.

Nick Stuffer

The installation described here, in the office of the President of Westinghouse Electric Corp. at Gateway Center, Pittsburgh, Penna., took second prize in the National contest for "My Most Interesting Lighting Job," after winning first place in the Cleveland Section and the Great Lakes Region. Mr. Stuffer is a project design engineer with the Commercial Design Section of the Westinghouse Lighting Division, Cleveland, Ohio.

Many of these "special requirements" were contrary to routine office conditions. While these may have added to the interest of the job, they most certainly also added to the lighting problems. Teakwood panelled walls were required, for instance, with traditional furniture. Appearance, with emphasis on dignity and relative elegance, was a prime factor, so that lighting systems employed had to conform to these factors. Further, the lighting system would have to provide a comfortable brightness ratio with the daylight brightness seen through a large picture window, 23 stories up.

Furniture arrangement in this 16 by 24-foot space divided the office into two separately functional areas. One end was a conference area, the other a work space. Lighting in the work area had to provide several levels as dictated by the visual task. At the conference table, two separate levels were required at different times — a comfortable level for conversation, and a somewhat higher level for reading letters and reports. Thus flexibility of the system presented still another challenge.

The resolution of these varying requirements involved a ceiling technique of rather new design. Around the perimeter of the office is an area of translucent plastic panels. Average brightness of

this area is 65 footlamberts, which is equivalent to the average reflected ceiling brightness produced by the upward light of a direct-indirect luminaire. This luminous ceiling area minimizes the harsh contrast of the luminaire brightness with that of the adjacent dark ceiling area and provides a comfortable brightness ratio between the inside and outside lighting conditions. This perimeter lighting is especially important on dark days and at night, when sufficient daylight is not available to illuminate the walls of the office.

General lighting is from two five-by-ten-foot luminous boxes, one over the work area, and the other over the conference area, so arranged that they serve each functional area without apparent division of the office. The luminous box element was designed to produce different levels of illumination at will, thus providing illumination flexibility at the work or conference area. Control of the corresponding brightness at each level required a specific lamp shielding device.

In the luminous box over the work area, nine rows of fluorescent lamps are spaced on different centers, grouped on three lighting circuits, producing three different levels of illumination. Five rows of lamps, grouped on two lighting circuits are used in the box over the conference area. The lamp layout in the luminous box over the work area required a greater concentration of lamps immediately above the desk, to place the light where it was desired. The shielding of these lamps was accomplished with 45° diffused aluminum louver assemblies. Inserted between the louvers and the lamps are translucent plastic panels attached to the louvers. This assembly makes the lamps invisible, by either direct view or by reflected lamp images on top of the furniture.

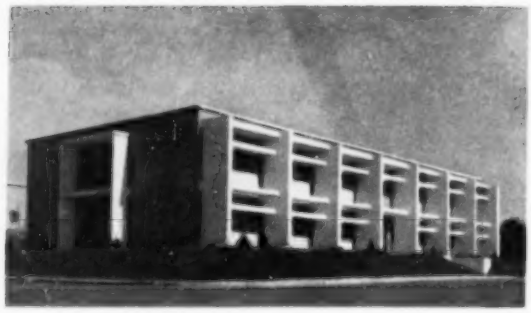
Average footcandles, measured at the desk, for each of the three levels, were 40, 75, and 100 footcandles. The readings at the conference table for the two levels were 30 and 55 footcandles. Measurements at the center of the office, where the ceiling is a 10-foot square of acoustical tile, were 15, 25, and 28 footcandles respectively.

Three pushbutton control stations are located at vantage points, and offer complete freedom of selecting any one of the three levels of illumination. Indicator lights were included to tell at a glance which level was in operation.

View of ceiling during construction shows two luminous boxes, ten-foot-square ceiling area, and plenum chamber of perimeter lighting panels.

THIRD

Floodlighting A Contemporary Building



A HAPPY solution to what appeared to be an almost impossible problem was the winning factor for this floodlighting installation. The building is the Office and Laboratory Building of the Mississippi State Highway Department, on U. S. Route 51, Batesville, Mississippi.

Architectural design was complete on this building, when the architects expressed an interest in floodlighting the facade, provided their very modest budget could cover the cost. For a traditional building facade, essentially a plane, the floodlighting problem is usually one of locating the proper sources at some convenient points in front of the building and aiming them.

In the contemporary architectural treatment of this building, however, a pattern of deep cells is created by a series of vertical baffles tied together by closely spaced horizontal beams. Architecturally, a plain rectangular brick building has been made interesting. There is a feeling of bold texture, of depth, where a two-dimensional flatness would have been. Functionally, the baffles and beams combine to shield the windows from the direct rays of the sun over a large percentage of the day, when the sun is highest. The white baffles add variety to the monotony of buff bricks.

A floodlighting system for such a design, however, was another matter. Assuming that convenient locations could be found for a conventional floodlighting system, unsightly shadow patterns from the cellular design were more than likely.

The system adopted was a practical, if unconventional, use of PAR-38 lamps in outdoor aluminum holders, mounted on the vertical baffles back-to-back, aimed at the opposite baffle in cross-fire fashion. These units are located between the horizontal beams for concealment.

No sources are aimed at the building proper. The buff-colored brick is illuminated only from the light reflected from the white baffles. This diffused light also washes out shadow patterns from the beams and reinforces the direct component. The result is evenly and brightly illuminated baffles, with lesser brightness on the bricks. This contrast and the dark front edges of beams and baffles preserves the pattern and depth of the facade at night.

The total job required sixty-eight 150-watt lamps for a total load of only 10.2 kw, in eight branch circuits. Control is by time switch and magnetic contactor in the feeder to the panelboard.

The "happy" features of the solution could be summarized as follows:

1. *Low Cost:* This pre-requisite was achieved by the use of very inexpensive fixtures, PAR-38 lampholders, and by mounting them on the building, thus requiring interior wiring only.
2. *High Efficiency:* The floodlamps are only 14 feet away from a white diffusing surface. The angle of incidence is practically 90 degrees. The viewing angles for motorists are also favorable for high brightness. Appreciable light is available by interreflections.
3. *No Glare:* Very little glare is caused inside of the offices because floodlights do not shine through the windows.
4. *Low Maintenance:* The floodlight lens front is

Mario G. Zervigon

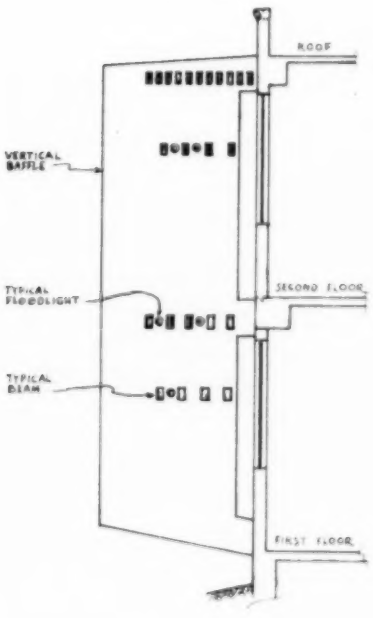
This installation took third place in the National Contest for "My Most Interesting Lighting Job," representing the Southern Region and the New Orleans Section. Mr. Zervigon is a consulting engineer with Louis N. Goodman and Associates, New Orleans.

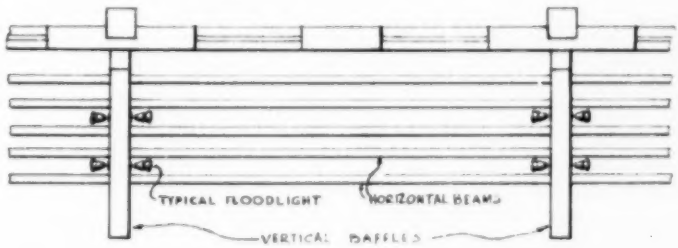
vertical and remains clean. The beams afford mechanical protection for the lamps. Relamping is simple because the baffle-beam structure serves as a scaffold for reaching the lamps. As is common to reflector lamp installations, a new reflector and lens are secured each time a lamp is changed.

5. *Architecturally Sound:* Architectural values have been preserved because the structural pattern of the front is still obvious at night. The brightness difference between baffles and brick wall enhances the feeling of depth. The third dimensional quality of the facade is not lost. The type of fixtures and the flexible arrangement lend themselves to the use of color for holidays. With color roundels over the lamps the possibilities for special effects are a challenge to the imagination.

Second floor section (right)

Elevation (below)





General Main Floor Area

Shoe Department

Modern Lighting for "The Grand"

COMBINING the comfortable atmosphere of a softly lighted living room with the high intensities of illumination necessary for the proper appraisal of merchandise is difficult, but the lighting of The Grand, a women's apparel store in Wauwatosa, Wisconsin, demonstrates how successful this approach can be. Following through on this approach, the designers of this store lighting installation avoided bare light sources or glaring brightnesses and yet made certain that the detail and sparkle of the merchandise would be emphasized. A major factor in the overall effect of this lighting design is the illumination of almost all vertical surfaces.

On the main floor, the general lighting system consists of fifteen shallow circular coves, each seven feet in diameter, plus a large number of recessed filament downlights. With the coves creating a pleasant, comfortable atmosphere and the downlights providing the appraisal lighting, from 40 to 80 footcandles of illumination is supplied over the entire ground floor. Each cove distributes the indirect illumination from eight 30-watt fluorescent lamps, and the coves are spaced, roughly, on 17 by 24-foot centers. The downlights are well shielded, equipped with 150-watt reflector flood lamps, and are spaced more or less at random, but with purpose, at an average of about six feet on centers.

Perimeter valances of various types completely rim the main floor area and provide the major part of the vertical surface illumination. The upward component from the valance lights the upper wall and ceiling, while the downward component illuminates the merchandise in the wall shelves and the niches.

In the shoe department, a special treatment is used to light the wall. Recessed lighting units, installed in the ceiling at the wall line, follow its saw-tooth pattern. These units are glazed with

Henry T. Koether

A fourth-place tie was awarded to this installation at the National Technical Conference in the contest for "My Most Interesting Lighting Job." This entry was the winning installation for the Milwaukee Section and the Midwestern Region of I.E.S. Mr. Koether is with the Wisconsin Electric Power Co., Milwaukee.

photographically-louvered glass, which process provides a 45° cut-off.

In the customer area of the basement, recessed units using silvered-bowl lamps in the center of a two-foot square louver furnish the general lighting. Elements of interest are added in the form of circular sections of louverall surrounding the tops of two columns in the area. Over the information desk, an 8 by 19-foot louverall ceiling supplies working illumination. Eight 16-foot rows of 96T8 slimline lamps operating at 200 milliamperes are located above the louverall. T6 and T8 slimline lamps operating at 200 milliamperes also furnish the light for the louverall circular areas around the columns. Two-hundred-watt silvered bowl lamps are used in the filament units.

Millinery Department

Other Areas

Lighting in other areas of the store is tailored to the specific merchandising or working need. A few of these areas are described below.

Millinery — This area is lighted by a complete louverall ceiling, approximately 14 by 15 feet in size. Twelve 12-foot single-lamp slimline strips housing T12 lamps operating at 430 milliamperes are located above the louverall. The strips are spaced on 18-inch centers. The fluorescent lighting of this luminous grid ceiling is supplemented with incandescent flood lamps, providing a combination simulating daylight. The high levels of illumination in this area, located in the rear of the store, also serves to draw customer traffic toward it, and of course, through other departments.

Bridal and Formal Salon — In this room, an atmosphere of glamor is of paramount importance, and suspended coves and a system of recessed equipment are used. The design of the room creates an impression of dignified privacy.

Dressing Room Areas — Fitting rooms throughout the store have flattering indirect cove lighting. In addition, there is general lighting from recessed ceiling equipment and auxiliary mirror illumination. Each room is a definite sales area, with emphasis also on comfort. Recessed equipment is in continuous rows of two-lamp 48-inch shallow fluorescent troffers, equipped with diffuse opal glass covers, spaced on six-foot center.

Show Windows — The entrances of the store, with a huge 16-foot high show window between, provide an inviting and interesting atmosphere. High level illumination, necessary for attraction and to combat reflections, is supplied by two-lamp slimline fluorescent fixtures with symmetrical porcelain reflectors spaced on about three-foot centers. Combined with these is the provision for continuous runs of 150-watt projector spot or flood lamps on 18-inch centers.

Stock Rooms — These areas are lighted with continuous rows of single-lamp slimline fluorescent strips. One row is centered in each aisle between the merchandise racks.

Offices — Good working illumination is provided by three-lamp, 48-inch fluorescent troffers, glazed with photographically-louvered glass, and spaced on six-foot centers.

Customer Area of Basement and Information Desk

Two-In-One Store Lighting

STORE LIGHTING plans vary with the merchandising problem — but the "most interesting" factor in this job was the dual use of a small store. Actually, the lighting layout of the store, Perlman's Jewelry in New Castle, Pa., involved three areas — show windows, a jewelry section, and the merchandising of appliances and TV sets, all under one relatively small roof, in a remodeled building. The major problem was to provide some sort of transition between the high levels required for jewelry and the more subdued levels desirable for the TV area, without distracting the customer with an abrupt change.

The front part of the store 23 feet wide and extending back 110 feet is devoted to jewelry. The store widens at this point to 44 feet, extending 70 feet more. This rear area contains the offices and a television and kitchen appliance department. In remodeling, the old 16-foot ceiling was lowered to 11 feet in the narrow front area, but the rear section is divided into two floors with only a 7½-foot foot ceiling on the first floor.

Show windows are in three sections — a shelf type window at the street for jewelry display, followed by a half window for larger items, and then a full window for TV and kitchen appliance display. Asymmetric reflectors with 200-watt bulbs were recessed on 16-inch centers with a resulting 450 footcandles at the street reducing to 300 footcandles in the full windows. Recessed adjustable spots were also installed for emphasis lighting.

Customers enter the store, of course, directly into the jewelry section. With an island floor case already included in the remodeling picture, the lighting system for this section was designed around it, using the 1-3-5-10 store lighting plan. This area is relatively narrow, compared to its length, so rows of eight-foot four-lamp slimline luminaires are mounted (flush on the 11-foot ceiling) across the store to add apparent width. The units are louvered, with plastic side panels, and provide a general illumination of 80 footcandles. The side panels have a brightness of 225 footlamberts. Maximum ratio of fixture to ceiling brightness is less than 20 to 1. To highlight the jewelry, 150-watt R-40 spots were recessed on two-foot centers over the front edges of the floor cases. These spots build up the intensity on the tops of the cases to 175 footcandles. All floor cases contain fluorescent tubes, which, combined with the overhead spots, provide 250 footcandles in the cases.

Wall cases with glass doors and shelves line each

Jewelry
Sales Area

Television Sales Area and Office

side of the store. These cases contain two continuous rows of fluorescent — one inside the case, and one in the canopy over the glass doors, providing 130 footcandles on the middle shelf of the wall cases.

The very low ceiling in the rear section ($7\frac{1}{2}$ feet high) dictated recessed equipment here. Two-lamp eight-foot troffers with low brightness louvers are installed, providing 40 footcandles in the sales area and 50 footcandles in the office.

The owner particularly specified a subdued atmosphere in the appliance section, so as not to emphasize possible minor flaws in wood cabinets of TV sets.

Louver brightness is 175 footlamberts. Adjustable spots are also used in this area to control store traffic and for emphasis lighting.

These two widely-contrasting departments presented a transition problem in the abrupt change from 130 footcandles to 40 footcandles and a ceiling drop from 11 feet to $7\frac{1}{2}$ feet. To avoid a "cave-like" feeling in the rear area, the back wall was brightened to provide a focal point for a customer approaching this area. The joist arrangement between the vault and the elevator permitted recessed line of fixtures parallel to the rear wall to make it uniformly bright. This wall was covered with a figured wallpaper to increase its attraction and contrast with the plain finishes of the other walls.

The ceiling drop between the two areas was concealed with a mirror, positioned on the upper wall between the two ceiling levels so that a customer entering the store would get the impression that the ceiling lighting in the front of the store extends over the rear section to the back wall. The mirror attracts customers towards the rear of the store with this illusion of added depth, until the bright rear wall draws them into the television sales area. These two additions, the bright rear wall and the mirror, combine to tie the areas together without distracting the customers' interest from the items on display.

L. E. Spears

This installation tied for fourth place at the National Technical Conference in the contest for "My Most Interesting Lighting Job." This entry was the winning installation for the Pittsburgh Section and East Central Region of I.E.S. Mr. Spears is Senior Commercial Representative for Pennsylvania Power Co., New Castle, Pa.

Direct Lighting for Schools

By H. L. LOGAN

Introduction

The lighting industry is unanimous in desiring to sponsor good lighting for schools. The I.E.S. School Lighting Committee's "Recommended Practice" was developed for this purpose, and has had a beneficial influence on practice. It was an attempt to apply within practical limits the principles enunciated in Report No. 1 of the S.Q.Q. Committee. This Report, although provocative of pro and con viewpoints from the beginning, and now made obsolete by the more recent data on brightness and comfort, was perhaps the best that could be written at the time.

These more comprehensive data demonstrate clearly that "brightness ratios can be misleading and require unjustifiable low fixture brightnesses."[1] They also indicate that low brightness ratios in the more remote parts of the visual field may not be of great importance. The data emphasize that brightness ratios depend upon the size of the luminous area of the light sources, their positions in the visual field, and the adaptation brightness. This was recognized by the original members of the S.Q.Q. Committee, but ignored of necessity as the available data did not permit them to develop a suitable relationship.

The present concepts of comfort appraisal — the Harrison-Meaker Glare Factor, Guth BCD Visual Comfort Indicator and Logan-Lange Comfort Factor — account for more variables than does the narrower brightness-ratio concept. Applying this kind of appraisal to the new, improved types of direct lighting installations shows these installations to meet proper comfort criteria despite their failure to meet, in all respects, the brightness-ratio limits of the I.E.S. School Lighting Committee's "Recommended Practice."

The original school lighting committee could not, of course, foresee the new data nor the improvement in optics that has since come about, and which has resulted for example, in lenses for incandescent lamps with a 25 per cent increase in output accompanied by a 40 per cent decrease in brightness, and a virtual cut-off at 45°; and in lenses for fluorescent lamps that have effective control of the light both lengthwise and crosswise with greatly reduced brightness in the 45°-60° zone, and a cut-off at 60°. This new equipment, properly applied and evaluated on the basis of the latest data, results in comfort factors in the range of 90 to 100 per cent. It fully meets the spirit and the purpose of the "Recommended Practice."

New Direct Lighting Techniques

An example of the new technique in low brightness, direct lighting incandescent lens units is shown in Fig. 1. The diagram at left shows the typical brightnesses in the field of view, and the photograph a typical classroom so treated.

Table I gives the comfort computation and from this it can be seen that 93 per cent of the possible occupants of the worst position in the room can be expected to declare themselves visually comfortable. It should be remembered that this refers to adults. Children who have not yet had time to build up the chronic muscular tensions characteristic of a percentage of adults and whose ability to accept as comfortable external stimuli (noise, brightness and so on) frequently astonishes adults, can be expected to be uniformly comfortable in this situation.

Fig. 2 shows the "heads down" position for work at the desk. There can be no question about the visual comfort of observers in this position, and if they raise their heads to the blackboard and become critically engaged with it, their comfort is now 100 per cent because critical engagement on the line of sight raises their comfort-discomfort threshold as pointed out by Guth. In this situation the summated glare effect becomes approximately 75/320, or 24 per cent, which means 100 per cent will be comfortable. The most severe situation is that of random looking around the room to which the estimate of 93 per cent comfort response applies. Incidentally the initial illumination level is 35 footcandles, with 200-watt lamps; which is the basis of the above computations.

The 20 to 1 brightness ratio recommendation of Table I of the American Standard Practice of School Lighting is limited to "visual fields." Only

[1] S. K. Guth, communication to author.

AUTHOR: Vice-President in Charge of Research, Holophane Co., Inc., New York, N. Y.

Figure 1a. (right) Typical classroom with direct lighting incandescent lens units. Comfort computation for this room is given in Table I.

Figure 1b. (below) Field of view for "Heads Up" position. Brightnesses shown in footlamberts. Adaptation level: 11 ft-L (mean brightness of field).

Figure 2. (below right) Field of view for "Heads Down" position. Brightnesses shown in footlamberts. Adaptation level: 26 ft-L (brightness of work).

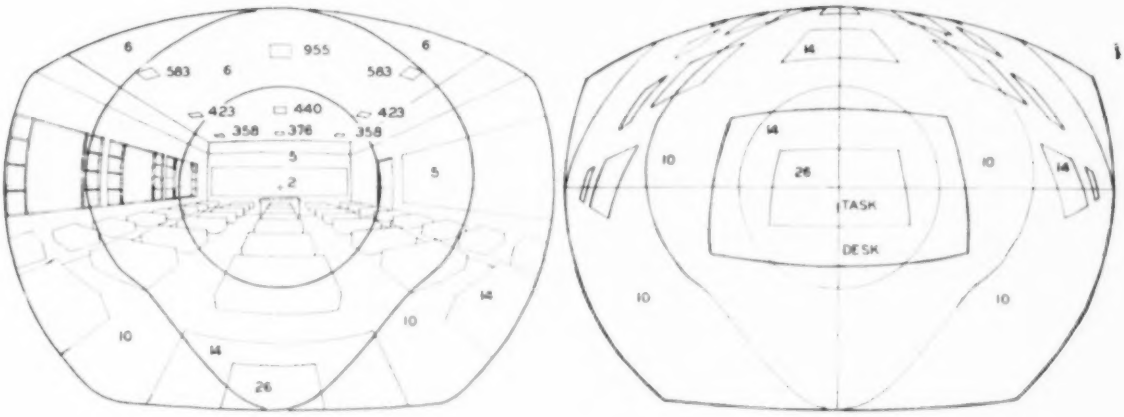


TABLE I.—Comfort Evaluation for Room Shown in Figure 1.

B Ft-L actual source brightness from spherical persp.	Q Sq. in. from illumineering work sheet	Q % of field $\text{Sq. in.} \times \frac{100}{250}$	P position index read directly	B' Ft-L $\frac{B}{P} = B'$ source converted to equivalent source on line of sight	Q' % when all $B' = 200$ from comfort chart transposition
358	0.08	0.032	1.9	188	0.066
440	0.11	0.044	2.6	169	0.064
376	0.04	0.016	2.1	179	0.029
583	0.40	0.16	6.0	97	0.046
423	0.10	0.04	2.6	163	0.052
955	0.35	0.14	6.0	159	0.165
					0.422

Total Area Q' 0.422

Installation Rating in % of "BCD" Brightness $\frac{150}{320} \times 100 = 47\%$

For adaptation level of 11.0 Ft-L.
This installation will be comfortable for 93% of Luckiesh & Guth's observers.

Figure 3. Classroom equipped with direct lighting, low brightness fluorescent lens units. Initial illumination level: 49 ft-c. Comfort computation for this room is given in Table II.

the "central" and "surrounding visual fields" are mentioned in the Table. The "surrounding visual field" is interpreted as a 30° radius cone, so that the 20 to 1 ratio applies to the lights and ceiling falling within the cone. This cone is the central circular area in the diagram in Fig. 2. The brightnesses of the lighting units in this area vary from 358 to 440 footlamberts, while the brightness of the ceiling is 6 footlamberts. The brightness ratio is therefore 60/73 to 1, which exceeds the recommended limit of 20 to 1. Nevertheless, the comfort factor of the installation works out at around 93 per cent, which emphasizes the arbitrary character of the 20 to 1 limitation.

In short, modern direct lighting systems, by using sharp control of the directions in which the light is emitted from the equipment, can illuminate visual fields with the same high degree of visual comfort as is expected from compliance with the "American Standard Practice of School Lighting," even though they do not meet the brightness ratio limitations laid down for lighting equipments.

Reflected Glare

An important but somewhat over-emphasized aspect of the problem of brightness relationships is reflected glare. Up till now this has been keyed to the brightnesses of lighting equipments, the same as the direct effect of such brightnesses. It was the obvious attack, but it was putting the cart before the horse. The underlying assumption was that reflected glare is a defect of a lighting system. Actually, reflected glare is always a defect of the field of view and not of the light that illuminates it. It is present with any kind of lighting system, natural or artificial, as long as there are surface characteristics that permit its occurrence; and it is absent with all kinds of lighting systems if the surfaces lighted do not generate it.

The best attack on reflected glare is therefore to specify and standardize the surfaces to be used in classrooms so they do not generate it. As a matter of record the practice of using non-glare finishes and surfaces has developed rapidly in the last decade, and few modern classrooms are guilty of the obvious glare reflecting surfaces that were common a generation ago.

Even when glare generating surfaces do exist in the field of view modern direct lighting systems are less of an offender than the indirect systems. The reflected glare from direct units is obvious and can be avoided by a change, often slight, in the position of the observer. The reflected glare from indirect systems is not affected by a change in position, cannot be dodged, and reduces visibility at all times. As long ago as 1938 Brown, Giannini and Robinson found this effect to be equivalent to a 30 per cent difference in illumination level, in the particular conditions they checked.

This effect is now being called "dimage" and recently G. P. Wakefield has published his study, "Control and Measure of Directional Flux at the Task," in which he concludes that "Direction of flux appears to be a powerful deterrent of dimage and as such may offer a challenging and bright future for engineers. Utilization of direction of flux may also suggest our next field of improvement in quality of illumination." That is, *properly*

TABLE II.—Comfort Evaluation for Room Shown in Figure 3.

B Ft-L actual source brightness from spherical persp.	Q Sq. in. from illumineering work sheet	Q % of field $\text{Sq. in.} \times \frac{100}{250}$	P position index read directly	B' Ft-L $\frac{B}{P} = B'$ source converted to equivalent source on line of sight	Q' % when all $B' = 200$ from comfort chart transposition
135	0.48	0.112	1.8	75	0.25
160	1.54	0.616	2.4	67	0.85
220	1.96	0.784	4.0	55	0.784
370	1.90	0.68	8.0	46	0.52

Total Area Q' 2.40

Installation Rating in % of "BCD" Brightness $\frac{55}{177} \times 100 = 31\%$

For adaptation level of 34.0 Ft.-L.
This installation will be comfortable for 100% of Luckiesh & Guth's observers.

controlled direct lighting appears to offer the best avenue for future improvement in lighting techniques; which suggests that the time is here to remove such handicap to this improvement as lies in the current version of the I.E.S. School Lighting Committee's "Recommended Practice."

Fluorescent Direct Lighting

To emphasize the fact that this improvement in direct lighting technique is not confined to incandescent equipment a classroom equipped with direct lighting, low brightness, fluorescent lenses is shown in Fig. 3.

Initial illumination level was 49 footcandles. The comfort computation is given in Table II and shows a comfort response prediction of 100 per cent, since borne out by the room's occupants.

Owing to the controlled distribution of this type of equipment its brightness will vary with its position in the field of view. As it emits the least light towards the eyes from angles near the horizontal distant units will be least bright. With those units the ratio to ceiling brightness is 10 to 1, well within the 20 to 1 limit of the "standards." However, being direct lighting equipment its brightness increases as the angle of view more nearly approaches the vertical, and the ratio to ceiling brightness rises to 27 to 1 for the nearest units.

On one interpretation of the A.S.P.S.L., 20 to 1 brightness-ratio limitation (where the "surrounding visual field" is interpreted as a 30° radius cone) this brightness ratio would not apply to the lighting units that fell outside of this cone, and would not therefore apply to the units nearest the observer in the installation shown in Fig. 3. On this technicality this type of installation could be considered as meeting the limitation, but it illustrates a point that needs clarification. Similarly this type of installation can be considered to meet the 0°-45° zonal brightness limitation if advantage be taken of the permissive clause doubling the value; but the over-riding fact is that the installation, without any technical quibbles, does produce the high quality lighting result contemplated by the Standard, which further shows that strict compliance with the A.S.P.S.L. is not the only avenue open to engineers to attain high quality lighting.

Conclusion

To summarize the foregoing, lighting equipment and methods are now in use that provide the quality lighting aimed at through the I.E.S. School Lighting Committee's "Recommended Standards" without meeting some of the specific requirements of those standards, or by meeting them only through interpretations that not all will agree to. This confusion can be most satisfactorily cleared by a suitable revision of the Standard. The writer suggests that the following principles be considered in connection with such revision:

(a) that mankind is adapted to specific natural lighting conditions and that these *particular* natural conditions are characteristic of *direct* lighting:

(b) that direct glare is not only a function of brightnesses, brightness differences and brightness ratios, but is equally a function of the areas and positions involved, and of the adaptation level of the observer in the particular visual field; and so direct glare is not susceptible to satisfactory control on the basis of brightness limitations and ratios alone, but requires some integrated method for its proper handling. Some of the available methods are the Harrison-Meaker Glare Factor, the Guth Visual Comfort Index, and the Logan-Lange Comfort Factor:

(c) that reflected glare is a defect of the field of view, and not of the light that illuminates it, and that attempts to reduce reflected glare by brightness restrictions tend in the direction of excessive dimage, which though less obvious is more serious than the reflected glare in classroom activities:

(d) and finally, that whatever limitations are adopted they be the same for natural and artificial lighting.

HINTS FOR A *Holiday*

Two residence lighting experts offer these ingenious lighting ideas to add to the gala festive look of your home at Christmastide.

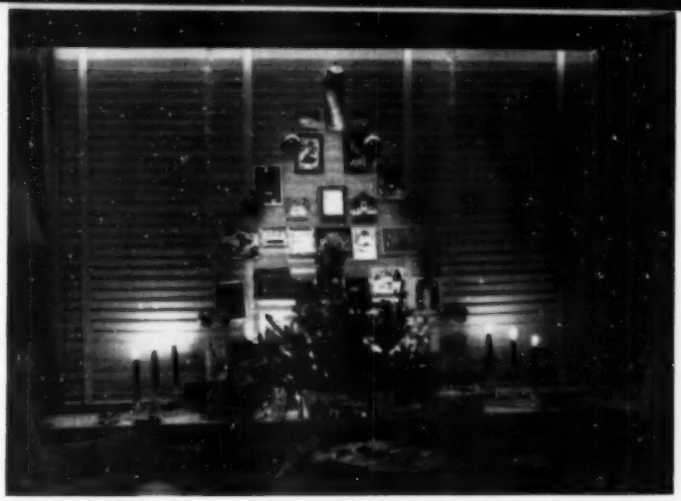
Long needle pine tips stapled to a cone formed of sheet plastic material form these miniature mantelpiece trees. Toy train lamps (in series strings) add sparkle. Inset drawing shows cone construction and lamp arrangement.

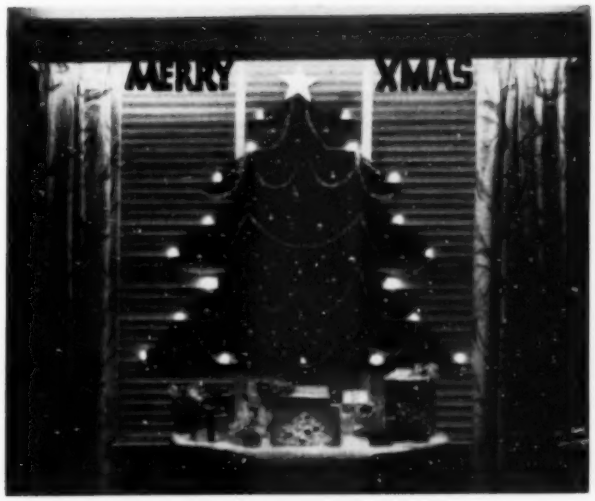
A cylinder of translucent plastic with a flame-shaped bulb at the top, plus two strings of C-6 series burning lamps, create a glowing candle (left). One string of lights is wound around the center pole of the candle and the second string circles the base as shown in the drawing above.

The table decoration at right can be constructed from simple materials. C-6 series burning lamps are strung around center pole; three graduated sizes of embroidery hoops are suspended from ribbons to form the tree shape; tree ornaments are hung from the hoops and the spaces filled in with "angel hair."

The ideas and photos on this page were submitted by Myrtle Fahsbender, Director of Residential Lighting, Westinghouse Electric Corp., Bloomfield, New Jersey.

House





Two ideas for making a Venetian blind "Christmas Tree" are suitable for an apartment or where space is limited. Above: a large bread pan covered with gold paper is filled with balsam boughs placed to simulate a real tree. A narrow cardboard box cut to the height and length of the pan is placed behind, with holes punched in the top. From these holes, multi-colored tree lamps silhouette the "tree," and with candles and valance lighting highlight the Venetian blind tree of Christmas cards and ornaments.

Left: Fire-resistant crepe paper, tree lights and a lighted star are the basic ingredients for this tree. With a china marking pencil outline a tree on the blinds and wrap each slat with strips of dark green fire-resistant crepe paper. Arrange lights in upright position, anchored with tape or clips. Conceal wires behind slats. Decorate with tiny colored ornaments and loops of tinsel and top it off with the lighted star.

A Christmas mobile, of figures punched from colored cardboard and suspended with black thread, is spotlighted by a projector lamp placed on the ceiling about four feet away. The spotlight is carefully louvered and stray light masked out to make a narrow beam. All the floating figures have at least one colored foil surface to reflect light into the room. For interplay of reflections and shadows when the mobile is moving, spotlighting from the front is the most interesting.

Ideas and photos on this page were submitted by Mary E. Webber, Residence Lighting Specialist, General Electric Co., Cleveland, Ohio.

Cold Cathode Ballasts

By R. C. HULTGREN

IN THE DESIGNING of any ballast for cold cathode lamps, two important cold cathode lamp characteristics must be taken into consideration. They are as follows:

(1) Cold cathode lamps have a negative resistance characteristic; i.e, as the current through the lamp increases the voltage falls.

(2) Cold cathode lamps rise in voltage during life.

First of all, let us consider the negative resistance characteristic: In order to satisfy this condition, inductance, capacitance or resistance, or a combination of two of these, or a combination of all three, must be used in series with the lamp in order to overcome the negative resistance characteristic of the lamp.

Secondly, the lamp characteristics, namely, the rise in voltage, must also be dealt with in any cold cathode circuit design.

Fig. 1 illustrates how this voltage rises during life in a standard type "HP" F.L.A. certified lamp. It becomes quite obvious, if the proper regulation is not built into the transformer or ballast, that the current through the lamp will drop as the lamp ages, thereby causing undue diminution in light output during life.

By building proper regulation into the ballast it is also quite obvious that the wattage in the lamp will rise during life. Due to the extremely long life and slow depreciation of the 120 ma T-8 cold cathode lamps in many cases the small extra current cost due to this rise in wattage can be overcome by the tremendous savings in lamp replacement and maintenance costs.

It has been found by testing lamps on lag-lead ballasts that the lead, or capacity circuit, held up very well in light output during life but in the lag, or inductive circuit, of a ballast of this type the current and light output dropped very rapidly as the lamp voltage increased. Fig. 2 illustrates the loss in lumens due to the increase in the respective lamp voltages in the lag and lead circuits of such a ballast.

Now, it is impractical at present frequencies to operate a cold cathode lamp with just capacitance because the wave form will be so poor that very low efficiencies will be realized; however, if a combination of capacitance and inductance is available, such as we have in the lead circuit of a lead-lag ballast, the wave form will be much improved and the lumen output will hold up very well as the lamp increases in voltage.

Fig. 3 illustrates a ballast circuit employing what is called the constant current principle; namely, the use of proper amount of inductance and capacitance in the lamp circuit to provide constant current through the lamp as the voltage of the lamp increases during life. (A single condenser with a center tap is used instead of two separate condensers purely for economic reasons.)

Another feature of the combination of capacitance and inductance in the lamp circuit is that the transformer or ballast can be designed so that with large variations in line voltage the ballast will deliver practically constant current to the lamps.

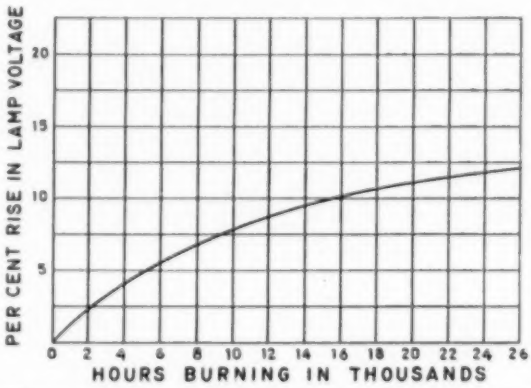


Figure 1. Voltage rise during life in standard type HP lamp.

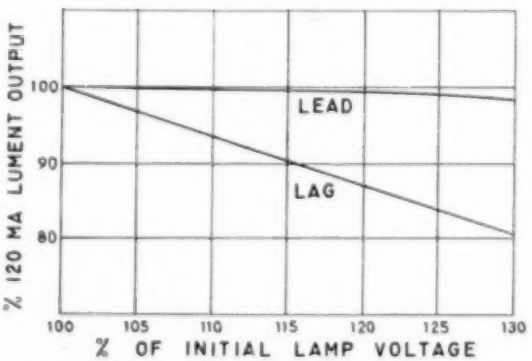
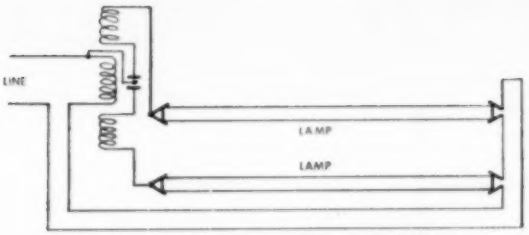


Figure 2. Lumen output vs lamp voltage in lead and lag circuits.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 14-17, 1953, New York, N. Y. AUTHOR: Vice-President, CELine, Inc., St. Charles, Ill.

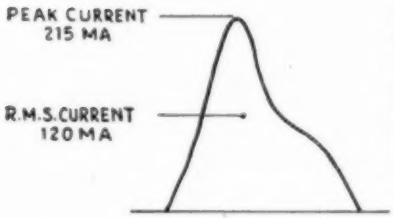


TYPE LP LAMPS – 7-9 LONG

Figure 3. (left) Ballast circuit using constant current principle.

Figure 3a. (below left) Current wave form for circuit.

Figure 3b. (below) Test on two ballasts. See Fig. 3.



LAMP NOS.	LAMP CURRENT	LAMP WATTS	TOTAL LIGHT	TOTAL PRI. WATTS	PRI. CURRENT
1	119 MA	39.2	8800 LUMENS	204 WATTS	1.77 AMPERES
2	120 MA	39.9			
3	120 MA	41.4			
4	120 MA	41.3			

LINE-118 V–OPEN CKT VOLTS-750V– BALLAST LOSS-42.2 W
OVERALL L.P.W. = 43

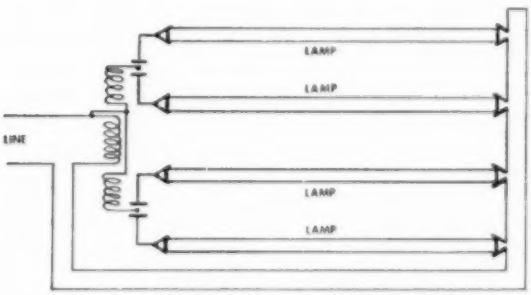
After meeting the two basic lamp conditions by the proper ballast or transformer design, it is also important to reduce the wattage loss in the whole combination of ballast and lamps. We speak of this as a combination because it has been found that if the wave form can be improved, not only is the wattage loss in the ballast decreased but the efficiency of the lamp is increased because when the current wave form is improved, the current through the lamp can be reduced still maintaining the same light output but reducing the wattage losses at the cathode.

In order to illustrate this fact, it might be best to go through some of the evolutionary developments that have taken place in cold cathode ballasts during the past three or four years.

The first ballast to be placed on the market of the capacitance and inductance type, illustrated by circuit diagram in Fig. 3, had a current wave form as shown in Fig. 3a.

The electrical readings and lumen outputs of four cold cathode type LP 3500K lamps operated on two of these ballasts are illustrated in Fig. 3b. The approximate lumens per watt in this system, including ballast losses, was 43 lpw.

In considering the large wattage loss of two of these ballasts, it was next decided to design a 4-lamp multiple type of ballast with two coils; 2 lamps operating from each coil and one condenser used to ballast each lamp. This circuit is illustrated in Fig. 4. Fig. 4a illustrates the current wave form obtained with this type of ballast, and Fig 4b illustrates the electrical characteristics of 4 lamps operated on this ballast.

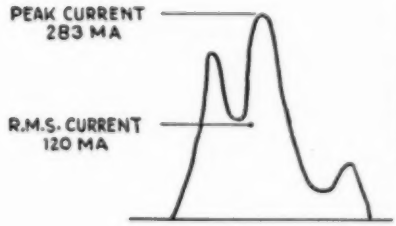


TYPE LP LAMPS – 7-9 LONG

Figure 4. (left) Four-lamp multiple type ballast with two coils.

Figure 4a. (below left) Current wave form for ballast.

Figure 4b. (below) Test on one ballast. See Fig. 4.



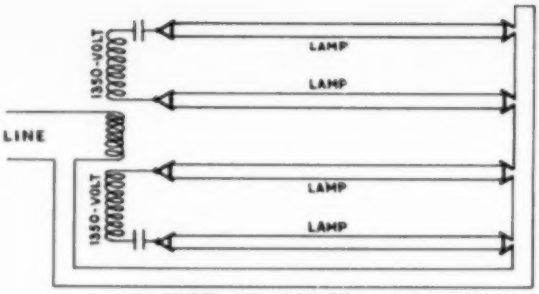
LAMP NOS.	LAMP CURRENT	LAMP WATTS	TOTAL LIGHT	TOTAL PRI. WATTS	PRI. CURRENT
1	123 MA	40 W	7600 LUMENS	188 WATTS	1.67 AMPERES
2	123 MA	37 W			
3	122 MA	40 W			
4	121 MA	40 W			

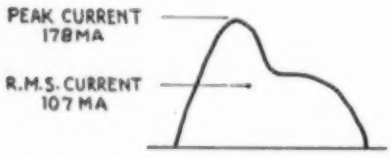
LINE-118 V–OPEN CKT VOLTS-750V– BALLAST LOSS-31W
OVERALL L.P.W. = 40

Figure 5. (right) New four-lamp series mid-point cut-out type ballast.

Figure 5a. (below left) Current wave form through the lamps with this ballast.

Figure 5b. (below right) Test on one ballast. See Fig. 5.





LAMP NOS.	LAMP CURRENT	LAMP WATTS	TOTAL LIGHT	TOTAL PRI. WATTS	PRI. CURRENT
1	108 MA	39.3 W	8800 LUMENS	186 WATTS	1.67 AMPERES
2	107 MA	38.8 W			
3	109 MA	38.7 W			
4	108 MA	38.9 W			

LINE-118 V—OPEN CKT VOLTS-SEE FIG. 5-BALLAST LOSS-30.3 W
OVERALL L.P.W. = 47

It is quite obvious that the lumens per watt values, including ballast losses derived from the data shown in Fig. 4b, is only 40 lumens per watt in spite of the fact that the ballast losses have been substantially reduced.

It is also obvious that the lamps are not operating efficiently due to the very high peak to rms ratio of the current when this ballast is used. Actually what happened in this development was that the efficiency of the ballast was increased but the lumen output of the lamps was reduced, due to the bad wave form of the ballast, so it would actually be better from an efficiency viewpoint to use two of the older type of ballasts as shown in Fig. 3.

Therefore, the problem confronting us was quite obvious: to design a ballast that would meet the requirements of constant current through the lamp during life, said ballast having low ballast losses, and producing good current wave form. Fig. 5 illustrates the circuit diagram of the new 4-lamp series mid-point cut-out type ballast. Fig. 5a illustrates the current wave form through the lamps when this ballast is employed. Fig. 5b illustrates the electrical characteristics of this ballast.

Upon examination of the above data, it is obvious that the output of the lamps has actually been increased in lumens per watt and the ballast losses reduced very substantially. By making a simple computation, one can see that the overall lumens per watt, including ballast losses, is actually 47 lumens per watt, and it is also interesting to note that for the same light output we were able to reduce the lamp current from 120 to 108 milliamperes. This increase in lamp efficiency that has been realized is partly due to this reduction in lamp current which reduces wattage losses at the cathodes thereby increasing the overall lamp efficiency. The remaining increases in efficiency are due to improved wave form and ballast losses.

It is to be noted that the ballasts used in circuits illustrated in Fig. 3 and Fig. 4 have an open circuit voltage of 750 volts, and, therefore, are only suitable for use with the F.L.A. low pressure (type LP) lamps rated at 15,000 hours.

If the high pressure (type HP) lamps are to be used, it is necessary to employ open circuit voltages of 835 volts, should the systems as illustrated in Fig. 3 and Fig. 4 be used.

One very important factor in the new mid-point cutout circuit development, shown in Fig. 5 is that either type LP or type HP lamps can be used; this makes possible very substantial reductions in wattage loss with both the LP and HP type lamps. (Practical rated life values up to 25,000 hours can be economically realized with type HP lamps at somewhat lower efficiencies than the 15,000-hour LP lamps.)

Conclusions

It has been the purpose of this paper to set forth the following facts concerning cold cathode ballasts.

(1) Any ballast designed for cold cathode (contrary to hot cathode ballast design) must cope with the rise in voltage of the lamp during life. The combination of capacitance and inductance in the circuit will accomplish this effect.

(2) It is very important in cold cathode ballast design that the current wave form through the lamps be given the utmost attention; the reason for this is that if the wave form is improved more light from the lamp can be realized,

the current through the lamp can generally be reduced, which in turn will reduce the losses in the ballast, increasing the ballast efficiency and also decrease the losses in the lamp cathodes, thereby further increasing the lamp efficiency.

(3) Four-lamp ballasts, or even 6-lamp ballasts should be used wherever possible, because while the units become large in size they are not too cumbersome for manufacturing purposes and ballast cost can be reduced along with ballast losses.

(4) The new mid-point cutout circuit not only provides much improved wave form, thus increasing ballast efficiencies and lamp efficiencies, but also with the same ballast permits the use of type HP lamps increasing lamp life to 25,000 hours along with increases in lamp and ballast efficiencies.

DISCUSSION

A. C. BARR*: Technical papers on cold cathode lamp design and operating equipment are always welcome. This paper is particularly interesting, for its study of the economics of 4-lamp ballasts is presented at a time when this ballast type is finding increasing use for the operation of both lamp types — hot and cold cathode. However, the paper does raise several questions in the minds of lamp and ballast engineers. Any additional information the author can give on these points will be appreciated.

Perhaps the principal question concerns the overall efficiency of these systems in view of the rising-voltage characteristics of the cold cathode lamps. While it is true that light output can be maintained in spite of the rising voltage if constant-current ballasts are used, it is also true that when this is done, lamp wattage steadily rises during life. As a result the designer must choose between better maintenance of light output during life (by the use of constant current ballasts), and constant wattage throughout life (by the use of lag circuit ballasting). In either case system efficiency will steadily drop during life; and at the same rate. Fig. 2 shows the effect of rising voltage on light output for the two circuits. It would also be useful to publish a similar curve showing the change in lamp wattage under the same conditions.

There is apparently a rather wide discrepancy between the rising-voltage curve shown in this paper (Fig. 1) and an earlier published work.[1] Reuter shows a 12 per cent rise for HP lamps at 8000 hours while Fig. 1 shows 7 per cent for the same period. Can the author offer an explanation for this difference in test results on apparently similar lamps? Further, the Reuter paper shows a 25 per cent rise in voltage for the more efficient LP type of cold cathode lamp. Does the author's experience bear out this difference, and can he advise us on the relative use of the two cold cathode lamp types?

The paper indicates that the differences in overall efficiency between the ballasts shown in Figs. 4 and 5 are due entirely to the change in circuiting — there is no indication that there may be differences in ballast design and manufacturing techniques that could account for a large part of the difference. Can the author tell us whether each design is the best of its type? Would it not be possible, by redesign of the components of the ballast shown in Fig. 4, to increase its efficiency to some point far more comparable with that given for the Fig. 5 ballast? Study of the wave shapes delivered suggests that something could be done along this line.

Finally, it is surprising to read that no additional starting voltage is required for HP lamps when two are operated in series. All our tests indicate that the starting voltage requirements for two lamps in series is only about 10 per cent less than the sum of their individual starting voltages.

*General Electric Co., Nela Park, Cleveland, Ohio.

R. C. HULTGREN*: Mr. Barr raises the question relative to voltage rise in the lamps during life. It must be remembered that the tests made by F. W. Reuter, Jr. were made some time ago, and that improvements in cold cathode emission materials have been made since that time. In fact, considerable improvements have been made since the time of the writing of this paper so that the voltage rise in the lamps is even slower than shown in Fig. 1. These improvements are prevalent in both the LP and HP type lamps. The rise, of course, will still be slower in the type HP lamps.

Mr. Barr also asks whether the overall efficiency between the ballasts shown in Figs. 4 and 5 may not be largely due to ballast designs and manufacturing techniques. The writer feels, however, that while it is true that a certain amount of increase in efficiency can be realized in the ballast by the choice of the correct component parts, nevertheless the great difference in the overall efficiency between circuits #4 and #5 is due mainly to the circuiting and not the choice of the correct component parts.

We have found, for instance, that if the required starting voltage of a lamp can be brought closer to the operating voltage, that the wave form can be improved.

We have also found that if the secondaries of transformers are independent from the primaries, in that an auto-type transformer is not used, that the wave form can be further improved.

We have further discovered that the wave form is made poorer by paralleling two lamps with condensers such as shown in Fig. 4. The writer feels, therefore, that it is largely the circuiting that has improved the wave form and rendered overall efficiencies.

Mr. Barr also states that it is surprising to read that no additional starting voltage is required for type HP lamp with this new ballast. In answer to the question, I might state that this ballast was made to operate either type HP or LP lamps and that it might be entirely possible that a small reduction in open voltage could be effected if type LP lamps were to be used only. However, it would not be of the same magnitude that, I believe, Mr. Barr has in mind. One of the main reasons when lamps are connected individually or in parallel on a ballast having an open circuit of the usual 750 volts, that an increase of this voltage is required for the type HP lamp, is that there must be enough excess voltage to satisfactorily start green lamps at high humidity conditions. It has been known for some time that with increased voltages the humidity has less effect upon the starting of the lamps. Therefore, when we connect two lamps in series on 1350 volts, such as shown in Fig. 5, the retarding of starting due to high humidity diminishes to a point where even 6mm lamps can be satisfactorily started.

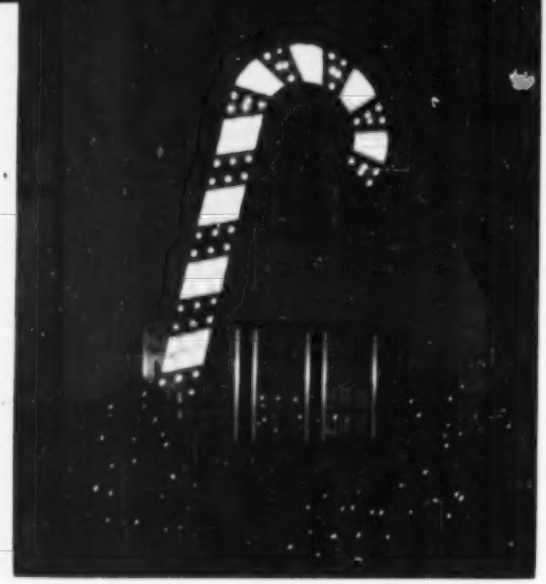
1. Reuter, F. W., Jr.: "Performance Comparisons of Hot and Cold Cathode Fluorescent Lamps." ILLUMINATING ENGINEERING, Vol. XLV, No. 6, p. 363 (June 1950).

*Author.

Light Your House

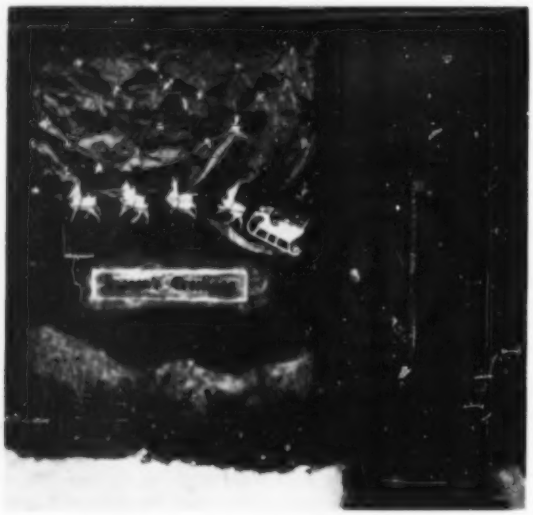
To Say

Merry Christmas



Cut out a huge candy cane, suspend it from the roof and sprinkle it with Christmas lights.

All photos courtesy of Miss Myrtle Fahsbender, Director of Residential Lighting, Westinghouse Electric Corp., Bloomfield, N. J.



A window covered from floor to ceiling with midnight blue foil makes a striking display. Santa and his reindeer ride through a star-studded sky made by poking Christmas tree lights through the foil into silver star reflectors. "Angel hair" and greens form a landscape.

This delicate window Christmas tree below is formed of tinsel strings suspended inside the window, trimmed with tree ornaments. Graduated candles at base of the tree and outdoor strings of lights around the window complete the picture.

Red-sheathed tubes with lighted flame cut-outs form graceful candles to decorate a house, as shown below. Projector flood or spot lamps, concealed near stairs, add sparkle and pine and holly trimmings put on the finishing touches.

Electrical Characteristics of Lamps and Ballasts

By W. CALVIN GUNGLE

Introduction

The fluorescent lamp is a gas discharge device; that is, it has a negative volt-ampere characteristic. Therefore, auxiliary equipment, (ballast) must be used with these lamps for their satisfactory operation. The ballast must be designed to impart to the system: (a) the necessary voltage for reliable starting of the lamp, or lamps, and (b) the proper ballasting to operate the system at the desired current. This design is complicated by the lack of correlation between the starting and operating characteristics of the lamps. During the starting the voltage is the independent variable and the current is the dependent variable while the reverse is true after a full arc has been established. These two parts must be matched electrically within the ballast to provide its proper performance.

The voltage necessary to initiate an arc in a given lamp varies over wide limits depending on the condition of the cathode, particularly its temperature, when this voltage is applied. This situation is well recognized and provided for in the various types of ballasts now available. These are:

1. Ballasts in which a sufficiently high potential is provided to start the lamps with cold filaments. The instant start ballast is of this type.
2. Ballasts in which only sufficient potential is supplied to insure starting with hot filaments, coupled with an inductive voltage surge at the moment the voltage is applied to the lamp. This is illustrated by the "preheat ballast" which, in conjunction with a starter, allows current to flow through and heat up the filaments for a short period. When the starter opens the ballast voltage is impressed across the lamp and its opening imparts the inductive kick which helps insure the establishment of the arc in the lamp.
3. Ballasts in which a potential slightly in excess of that needed for ballasting is provided for starting. Satisfactory starting with a potential this low is obtained by continuous heating of the filaments by separate transformer windings to a temperature for good emissivity. This is illustrated by the "rapid-start ballast" which has been described recently.[1]

In view of the present interest in the last method of starting and operating lamps, this paper will be largely confined to a discussion of the effect of filament emissivity on lamp characteristic curves particularly at low currents.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 14-17, 1953, New York, N. Y. AUTHOR: Sylvania Electric Products Inc., Salem, Mass.

Lamp Characteristics

As implied in the introduction, a ballast must furnish an output potential at low currents (current below arc operation) in excess of that needed for lamp operation. This potential should decrease with increasing current in such a fashion that it equals the voltage drop across the lamp or lamps at the desired operating current. Operation such as this defines a point of stable equilibrium for the system.

The graphical representation of the voltage-current relationship of a ballast is known as the ballast load line. A typical curve of this type is shown in Fig. 1. This is for a typical rapid start ballast designed to operate two 40-watt lamps in series.

In this same figure is shown the characteristic curve (*i.e.*, relationship between lamp volts and current) for two 40-watt lamps in series with all four filaments heated to a good emitting temperature. This curve intersects the ballast load line at

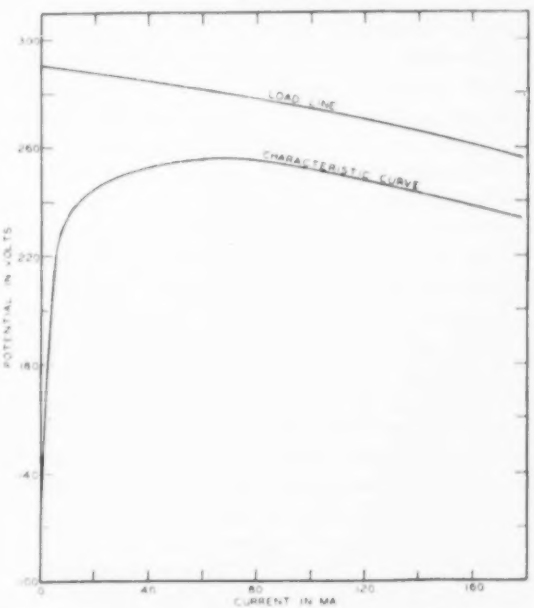


Figure 1. Electrical characteristic curve for two lamps in series and rapid start ballast.

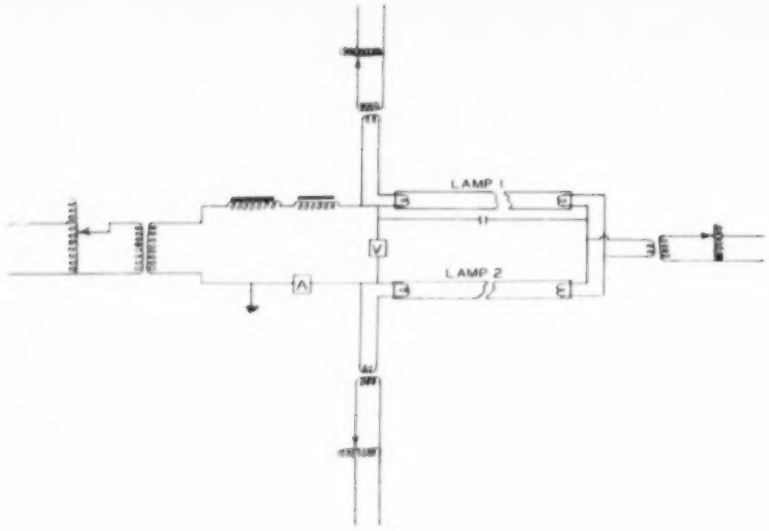


Figure 2. Circuit for measuring electrical characteristics of two lamps in series.

approximately 425 ma (not shown on chart) and that point of intersection establishes the operating current of the system.

The characteristic curve of the lamps in Fig. 1 was determined with the circuit shown in Fig. 2. This is essentially the type of circuit used in rapid start ballasts except that separate transformers are used to heat the filaments. By means of this modification, the voltage applied through the ballasting across the lamps can be varied without affecting the heating of the filaments. In this experiment, the filaments were continuously heated with the current determined previously to give satisfactory starting. The lamp characteristic curve in Fig. 1 is the resultant relationship between current and voltage across the lamps.

Notice in this figure that the current through the lamps increases along a smooth curve. Since the light output is a function of the current, a continuous increase in emitted light from the lamps will result during this establishment of the arc in the lamps. This gives a lucid picture of the smooth type of starting of fluorescent lamps obtained with this system.

When one, or more, filaments in this system are not properly heated, the lamp characteristic curve will be raised along the voltage axis in the low current, or glow, region of the curve. For example, the characteristic curve of the lamps with one of the filaments left cold is shown in Fig. 3. The ballast load line and characteristic curve of Fig. 1 are repeated here for comparison purposes.

As shown in the figure, a higher voltage is necessary across the lamps to draw the glow currents below approximately 60 ma. A current of approximately this value, however, is apparently sufficient to bring the temperature of the cold filament up to proper emission. When this occurs, the potential across the lamps drops to a value approximately the same as given by the other characteristic curve in this figure and at currents above this value the two curves are identical.

In Fig. 3, it will be noticed that the characteristic curve of the lamp just discussed intersects the ballast load line at approximately 32 ma. As dis-

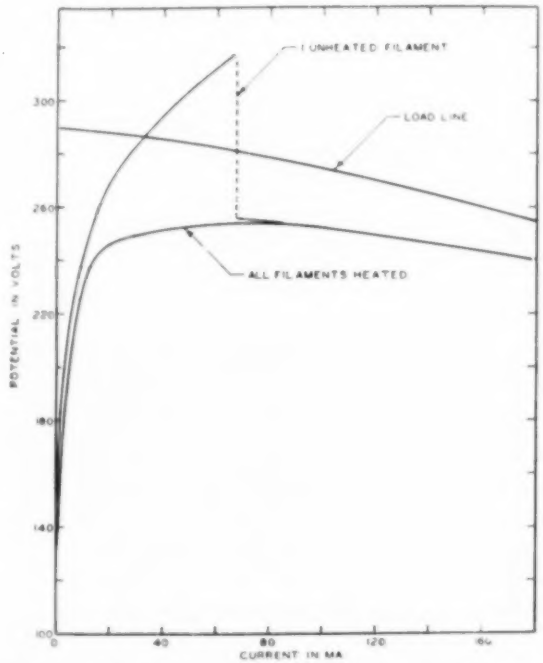


Figure 3. Effect of unheated filament on characteristic curve.

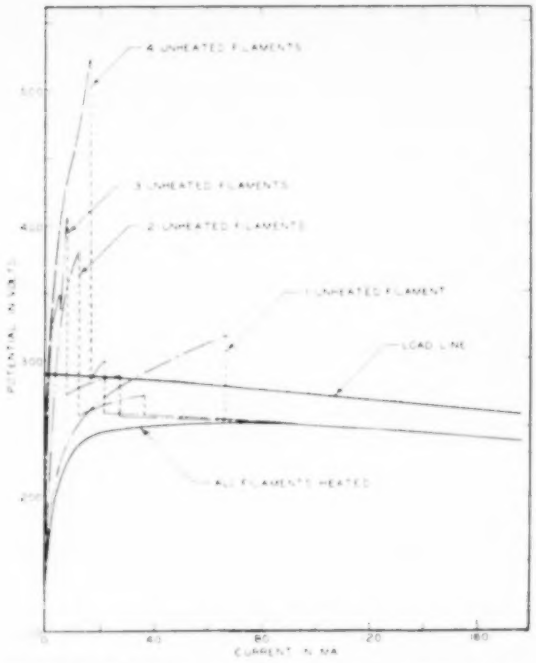


Figure 4. Effect of unheated filaments on characteristic curve.

cussed above, such an intersection defines a point of stable operation. Therefore, such lamps with one cold cathode when operated on this type of ballast whose load line is shown, will operate at 32 ma, maintained at that point by the potential barrier indicated by the difference between the peak on the characteristic curve and the ballast load line. In this case a surge of approximately 35 volts will be required to carry the lamps up over the hump and into the full arc.

In Fig. 4, the characteristic curves of the lamps with all possible combinations of heated and cold filaments are shown. In these experiments it was found that the curves were determined solely by the number of filaments heated and not which filaments were heated.

As can be seen, as the number of cold filaments increases, the voltage necessary to bring the current up to the value at which bombardment raises the temperature to that for proper emission also increases. It is interesting to note the number of transitions which appear in these curves. They are apparently dependent on the number of cold filaments, *i.e.*, with no cold filaments, no transition; one cold cathode, one transition; two cold cathodes, two transitions, etc. Although the curve with all four cathodes cold shows only two distinct transitions, in taking the experimental data four transitions were actually noticed. These results would be expected since no two cathodes are identical as far as emission properties are concerned. Thus, the bombardment current which will bring the filament up to proper emitting temperature will be different for each.

The poor emitting properties of cold cathodes can be illustrated by oscilloscope traces of the current wave forms in a single lamp as shown in Fig. 5. In the half cycle in which the heated filament is the cathode the lamp is conducting, during the half cycle when the cold filament is the cathode, it is not. If the voltage across the lamp with the cold filament is increased, a sudden transition can be noticed when the unheated filament begins to emit properly and the wave assumes a shape similar to that shown for both filaments heated.

The characteristic curves discussed here are only for the extreme cases which would be obtained if one or more of the filament circuits of a fixture were open-circuited. With partial heating of the filaments such as might be obtained with poor contacts in these circuits, intermediate characteristic curves would be obtained. However, these curves in conjunction with the ballast load line illustrate very clearly why poor starting can be encountered in rapid start installations. These experiments were performed with warm and well-aged lamps. With cold and unaged lamps, the voltages would be somewhat higher.

Effect of Contact Resistance

The effect of improperly heated cathodes can be further illustrated by the increase in starting voltage for two lamps in series as a function of resistance added to the heating circuit. In these experiments, the same circuit shown in Fig. 2 was used

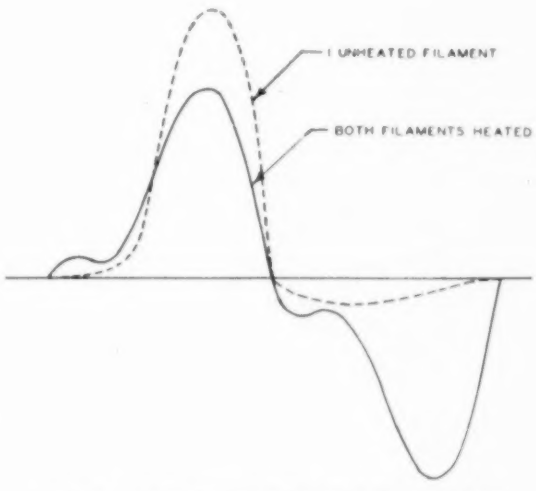


Figure 5. Current wave forms of a lamp at 50 ma.

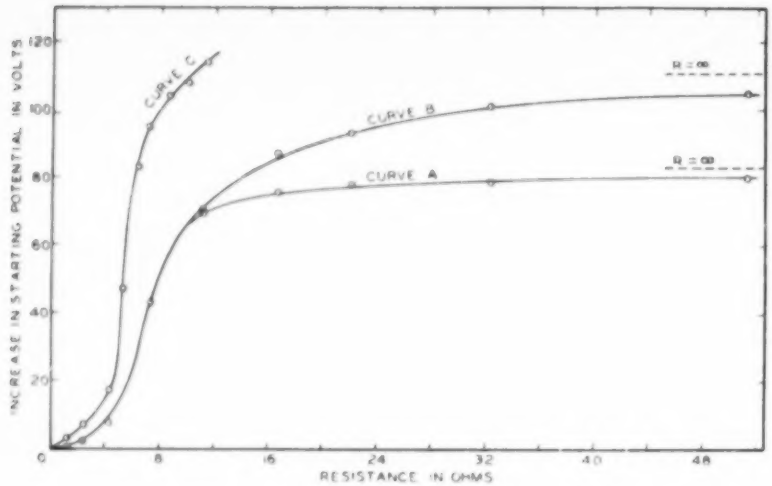


Figure 6. Effect of resistance in a filament circuit on starting.

Curve A. Lamp No. 1

Curve B. Lamp No. 2

Curve C. One filament each of Lamp No. 1 and Lamp No. 2

with resistances placed in one of the filament heating circuits, and the voltage required to start the lamps determined. The increase in starting voltage as a function of the added resistance is shown in Fig. 6.

These curves have a hyperbolic shape up to about 7 ohms added resistance. Above this value of resistance the curves flatten out and approach the value for infinite resistance (open circuit) asymptotically. As would be expected, the effect of resistance added to two filament circuits simultaneously is considerably greater than when added to only one.

By reversing the resistance scale of Fig. 6, curves as shown in Fig. 7 are obtained. These curves are similar in shape to those of starting voltage as a function of filament voltage which have been published previously.[1] This illustrates that the effect of resistance added to the filament heating circuits is to decrease the voltage applied to the filament thereby decreasing its temperature and thermionic emission.

These curves indicate that any resistance in the filament heating circuits will introduce difficulties in startability of rapid start fixtures. Contact resistances between lamp pins and holders of a magnitude to cause such difficulties can be found in the field, especially in the presence of corrosive atmospheres. For example, some lamp holders with brass contacts were placed in a humidity chamber at 95 per cent relative humidity. After seven weeks in this atmosphere, the resistance between a lamp pin and the contacts was measured and found, in some cases, to be above 10 ohms. It has been our experience that a fixture with such a pin-to-contact resistance would not start properly. Work is being carried out in our laboratory at the present time with non-corrosive type contacts to mitigate this

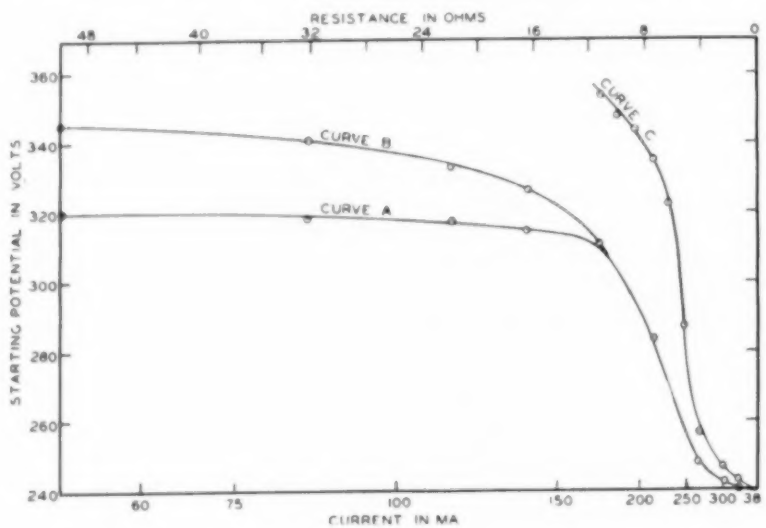


Figure 7. Effect of filament heating current on starting

Curve A. Lamp No. 1

Curve B. Lamp No. 2

Curve C. One filament each of Lamp No. 1 and Lamp No. 2

situation where corrosive atmospheres are encountered in particular installations.

Conclusions

The electrical characteristic curve of a fluorescent lamp, or lamps, is a guidepost for the design of a ballast to be used therewith. Such curves are also useful in analyzing difficulties which may be encountered and can help to establish the limits of adverse conditions which can be tolerated.

Acknowledgments

I would like to take this opportunity to express my appreciation for the assistance rendered by Dr. E. F. Lowry and Charles W. Jerome, both of this laboratory, in the preparation of this paper.

References

1. Lemmers, A. E., and Brooks, W. W.: "New Fluorescent Lamp and Ballast Design for Rapid Starting," ILLUMINATING ENGINEERING, Vol. XLVII, p. 589 (1952).

DISCUSSION

A. W. WEEKS*: I want to compliment Mr. Gungle on his clear, concise presentation of information about the characteristics of the rapid start lamp and its adjuncts. His paper is the result of much constructive work and points up some of the factors which must be further explored.

May I suggest that the word "watts" be substituted for "current" in the sentence "Since light output is a function of the current . . ."

The effect of contact resistance is well presented and this source of trouble should be eliminated as rapidly as possible for there are many lamps and sockets in service which are potential trouble makers.

I presume all of Mr. Gungle's measurements were made with a starting aid strip.

R. N. THAYER**: The main thesis of this paper is the lamp starting difficulty likely to occur in 40w F series rapid-start circuits if some or all of the lamp cathodes are unheated or inadequately heated. It is a more thorough and detailed coverage than the brief discussion of this same point last year on the Lemmers-Brooks paper, which is listed as reference. There can be no dispute with the main thesis. Supplementary cathode heat is essential to realize the advantages of rapid start operation, and its omission or substantial reduction is bound to affect lamp performance adversely.

The important question suggested by this paper is how frequently customer service conditions may produce circuit resistances leading to the starting difficulties shown. Both our laboratory tests and customer experience to date indicate that such troubles are not encountered in normal usage.

In our laboratory checks, we turned lamp bases into sockets as they would be in normal use, and submitted 30 such combinations to these tests, with the resistance results shown:

1. Controls. Held in cabinet. Ave. R, .21 ohm; max. R, .49 ohm.
2. 87½ hrs. at 100 per cent relative humidity and 100°F. Ave. R, .33 ohm; max. R, 1.08 ohms.
3. 44 hrs. in closed container over aqua regia. Ave. R, .03 ohm; max. R, .06 ohm.
4. Salt spray directly on base-socket combinations, 16 hrs. on — 8 hrs. off for 64 hrs. at 95°F. Ave. R of 21 samples, .29 ohm. Nine showed open circuit under this abnormal condition, in which the parts were encrusted with a salt deposit. As soon as the lamp base was turned slightly, normal contact resistance was re-established.

Fig. 6 of the paper shows that all R values found have negligible effects on starting volts.

In field experience, over half a million 40-watt rapid-start lamps are now in service, with excellent results. From these, only 18 complaints have come to us. Most of these have been attributable to improper wiring, defective ballasts, improper lampholder spacing, or other causes which would have resulted in unsatisfactory performance of any type of fluorescent lamp. None was definitely attributable to high-contact resistance.

For those rare lighting installations in which exposure to corrosive or high-humidity atmospheres is continuous, further tests and use may be in order to determine the acceptability of the rapid start system.

One or two further comments deserve mention. In lag ballast circuits of whatever type, one cathode often "fires" or "hot-spots" several cycles before the other. This is the case in Fig. 5, and is harmless unless it persists. The transitions, shown in Figs. 3 & 4, which occur as the cathodes reach operating temperature or "hot spot" are well known, and are the same transitions often encountered in starting F lamps on all types of circuits.

R. F. TOWNSEND*: The data and curves published in this paper serve to show that there is a possibility of starting difficulty with rapid start lamps under adverse operating conditions of unheated or partially heated cathodes. In actual service to date, our examination of many Rapid Start field installations under various operating conditions has not shown any starting difficulty resulting from these causes.

The possibility of a complete unheated cathode will seldom be encountered. The causes of completely unheated cathodes in a Rapid Start installation, such as a defective ballast, broken lamp filaments, faulty connections, incorrect wiring, etc., can also happen in a preheat type installation and our experience with preheat installations over these many years has shown no user hardships resulting from such conditions.

However, starting difficulty in rapid start installations as a result of partially heated electrodes caused by abnormally high contact resistance between the lamp pin and the socket might be encountered. This difficulty is peculiar to rapid start lamps but is only one of many which apply to all types of fluorescent lamps and which have been overcome by industry action.

It is desirable that the information in this paper be brought to the attention of the lighting industry as it is the responsibility of lamp, ballast, socket and fixture manufacturers to anticipate potential difficulty and correct for it in their product design.

In our lamp design and manufacture, we are determined to do what we can to make the rapid start system a success.

*Champion Lamp Works, Lynn, Mass.
**Lamp Development Laboratory, Lamp Division, General Electric Co., Cleveland, Ohio.
*Commercial Engineering Department, Westinghouse Lamp Division, Bloomfield, N. J.

Our lamps pass such rigorous starting tests that we believe we have compensated for such contingencies as contact resistance. We are sure that others in the lamps and lighting industry will do their part too.

W. CALVIN GUNGLE*: The main purpose of this presentation has been to further establish the important relationship which exists between lamp characteristics and the ballast load line. Briefly, the situation may be stated as follows:

> At no time may the characteristic curve of a lamp or lamps exceed the load line of the ballast used therewith until full operating current has been reached for proper operation of the system. This statement holds regardless of the starting method involved.

The type of study presented concerning the electrical characteristic curves of lamps and ballasts is applicable to all sizes and types. For those of other sizes than the 40-watt, the absolute values of the parameters will be different but the resulting curves will exhibit shapes similar to the ones presented.

The phrase, "since light output is a function of the current" is more applicable than the way suggested by Mr. Weeks in view of the fact that a curve of the voltage as a function of the current is shown and a discussion of it is being made.

All the data presented were obtained with the use of a starting aid strip.

The contact resistance data presented by Mr. Thayer involved very short testing times of less than four days. This does not appear to be adequate to give reliable indications. Our tests were run for seven weeks but even this length of time is insignificant in comparison to the five or more years during which any installation should furnish reliable operation.

I agree with Mr. Thayer that in installations in which exposure to corrosive or high humidity atmospheres is continuous, further tests and use may be in order to determine the acceptability of the rapid start system.

In Fig. 5, the situation shown in which one filament was left unheated is a stable condition and will persist. It is not a transient condition as suggested by Mr. Thayer.

The transitions in the curves of Figs. 3 and 4 result from hot spot formation when adequate external heating is not supplied. With a properly operating rapid start installation these transitions are not encountered as pointed out in the discussion of the characteristic curve shown in Fig. 1 of this paper.

As Mr. Townsend points out, the rapid start method of starting and operating lamps offers many advantages. As a result we are all concerned with doing everything possible to make it work satisfactorily. This paper has been intended as a constructive criticism of the system and as an aid in a better understanding of it.

*Author.

Design Characteristics of a Photo-Electric Brightness Meter

Discussion and Rebuttal of paper by KARL FREUND

(Published October 1953 ILLUMINATING ENGINEERING, p. 524)

W. H. BILLHARTZ*: My colleagues and I have been using one of the meters discussed in this paper for about two months. We have found it to be an excellent piece of equipment.

At the I.E.S. National Technical Conference in 1952, in Chicago, we described a physical brightness meter which was designed to integrate the brightness of a relatively larger area than is the Spectra Spot Brightness Meter and it has proven quite satisfactory. It would not, however, be a substitute in most cases for the meter described by Mr. Freund.

We have found that the Spectra Spot Brightness Meter we use is very stable and after a few minutes warm-up period displays negligible drift over a period of at least one hour. I have not had time to calibrate the instrument against fundamental standards, but I have no reason to question its calibration.

The only suggestions that I have to offer for its improvement are:

(1) More divisions on the scale of the micro-ammeter especially at the upper end of the scale,

(2) A less sensitive zeroing adjustment.

In my opinion the meter is a quite welcome addition to the working tools available to the illuminating engineer and to the researcher desiring to measure brightness. It is particularly convenient to be able to connect the meter to a continuous recorder.

Since one often has available a number of micro-ammeters I should like to ask the author to tell us the desirable range in micro-amperes and the desirable resistance for an external meter which one might like to calibrate to the instrument.

KARL FREUND*: With regard to the suggestions offered by Mr. Billhartz on more divisions on the scale of the Spectra Spot Brightness Meter and a less sensitive zeroing adjustment:

(1) The micro-ammeter used in the meter has a logarithmic type response which means that the per cent readability is approximately the same over the entire range. However, if greater readability in the upper end of the scale is desired, the larger linear external meter should be used.

(2) A less sensitive zeroing adjustment is being incorporated in all the meters being produced now, although it is necessary to have a fairly large range in the zero adjustment in order to compensate for the shift in zero position due to temperature changes and the age of the batteries.

As to the sensitivity required for external micro-ammeters, this will vary somewhat from meter to meter. Records are kept at Photo Research so that the external meter can be furnished for any instrument to read directly in footlamberts. A meter with a sensitivity of 150 microamps and a resistance around 1500 ohms could be used to obtain the relative readings.

*Product Development Physicist, Pittsburgh Corning Corp., Port Allegany, Pa.

*Author, Photo Research Corp., Burbank, Calif.

INSTALLATION AT ART MUSEUM OF NEW BRITAIN INSTITUTE, STANLEY WING, NEW BRITAIN, CONNECTICUT.

Lighting an Art Museum

LIGHTING OBJECTIVE: To provide inexpensively (1) suitable vertical perimeter lighting for oil paintings and (2) lighting for occasional displays on tables in the center of the room.

GENERAL INFORMATION: This 32 x 60 x 12-foot gallery (with 45-degree corners) is decorated as follows:

ceiling	oyster white acoustical plaster	50% RF
walls	beige fabric	44% RF
floor	light green cork carpet	13% RF

INSTALLATION: Thirty fluorescent luminaires (Light Control F74) are mounted on the ceiling in a rectangular pattern, with four special 45-degree mitred units for the corners. The standard luminaire, shown in Fig. 3, was specially equipped with a center baffle and contains four 40-watt standard warm white lamps; the corner units each contain two 20-watt lamps on the room side with two 30-watt lamps on the wall side. The two lamps on the wall side can be used alone to illuminate the oil paintings, with no light source visible to the observer. Clear Pluralite glass was used on the wall side of the units to give a maximum of light on the pictures, and Pluralite ground glass on the room side to reduce brightness. The lamps directed toward the center of the room are used only for occasional displays in the middle of the room.

The average vertical illumination on the paintings with the outer row of lights only is 20 footcandles maintained in service and 32 footcandles with all lamps on. The average horizontal illumination is 5 and 22 footcandles under the same conditions.

(over)

A.I.A. File No. 31

Figure 2. (left) Luminaires with all lamps on to illuminate display in the middle of the room.

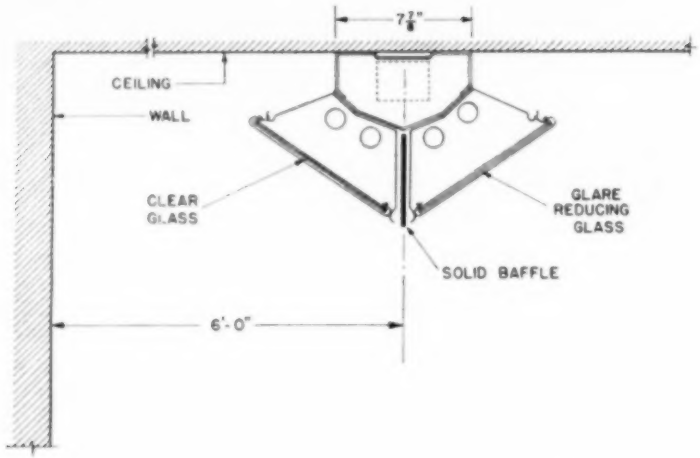


Figure 3. (right) Luminaire detail showing spacing with respect to wall and ceiling.

Brightnesses are as follows:

	Footlamberts	
	All lights on	Outside row of lights only
luminaires (viewed from center of room)	1401	3.75
ceiling molding	16	12.4
upper wall	36	34.7
between pictures	30	18.7
lower wall	24	11.5
floor	16	5.4

The museum board of directors was so pleased with this installation that many of the galleries in the older part of the building were relighted in a similar manner.

Lighting designed by Harold Young, Litecontrol Corp., Watertown, Mass.; Architects: Delbert K. and John Perry, New Britain; Electrical contractor: Peterson Electric Co., New Britain.

Lighting data submitted by C. W. McCormick, Connecticut Light and Power Co., Waterbury, Conn. and Harold Young, Litecontrol Corp., Watertown, Mass. as an illustration of good lighting practice and to aid in the design of similar installations.

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Efficiency and Appearance Factors In Luminous Panels

By M. E. HASKINS, JR.

The purpose of this paper is to provide lighting designers with new data showing the effect on efficiency and appearance of luminous elements when varying the spacing relationships of fluorescent lamps and the transmittance of diffusing corrugated plastic.

THE NATURE of the task suggested three main steps in the procedure. First, a standard for judging appearance of luminous panels was obtained in terms of brightness contrast. Second, data on brightness values and brightness distribution were obtained for each variation in design. These data were converted into terms of efficiency and brightness differences. Third, the results in step two were interpreted using the standard obtained in step one.

Equipment Used

The equipment used is shown in Fig. 1. A box, 36 x 49 x 42 inches was constructed, open on front and back and equipped with two movable backs. One back consisted of 192 medium screw sockets on three-inch centers. The other back consisted of 12 pairs of medium bipin fluorescent lampholders with three-inch spacings. All surfaces were painted a flat white of 80 per cent reflectance. Lamps were seasoned and read for lumens. Four corrugated, acrylic plastic panels varying in thickness from one to three-sixteenths of an inch and having transmittances of 50, 60, 70, and 80 per cent were used as diffusers on the front of the box.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 14-17, 1953, New York, N. Y. AUTHOR: Commercial Engineering Dept., Westinghouse Lamp Division, Bloomfield, N. J.

Readings in Part I were made with a Luckiesh-Taylor brightness meter. Those in Part II were taken with a color-and-cosine-corrected Model 603 Weston footcandle meter equipped with a specially made cover having a three-quarter by three and one-half inch slit as shown in Fig. 2. The combination was calibrated so that footlamberts could be obtained by multiplying actual readings taken on the panel surface by 16.75.

For convenience, the following names and symbols will be defined:

Lamp Height *(h)* — The distance from the center plane of the plastic diffuser to the axis of the fluorescent lamps.

Lamp Spacing *(S)* — The distance between the lamp axes of adjacent rows of equally spaced fluorescent lamps.

Efficiency — The ratio of transmitted flux to lamp flux. Transmitted flux was calculated by multiplying the average brightness of the diffuser in footlamberts by its area in square feet.

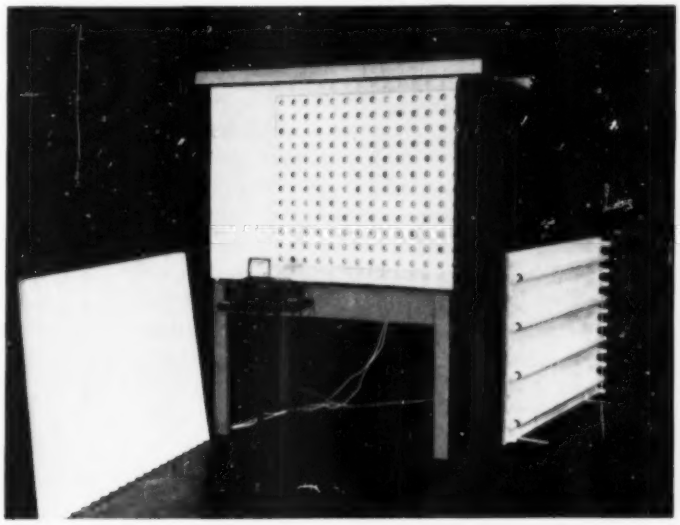

Fig. 1.—View of test equipment: the variable depth box, two types of movable backs, stacks of diffusers, and measuring instrument.

Fig. 2.—Close up of footcandle meter showing slit attachment used in test.

Brightness Difference (ΔB) — The difference between maximum and minimum adjacent brightness ($B_{max} - B_{min}$). The readings were obtained as the meter was moved continually over the surface of the diffuser from the maximum deflection through the minimum on either side. Maximum readings were usually opposite lamps and minimum between lamps.

Cavity — The volume enclosed by the four sides, back and front.

Part I — Evaluation of Appearance

The first step was to provide a physical scale by which to evaluate the appearance of luminous panels. The assumption was made that apparent uniformity was the most desirable goal.

Since the published data[1,2,3] presently available were not directly applicable to this work, a simple test was undertaken to arrive at a relationship between brightness level and maximum non-objectionable contrast. It consisted of two parts, one using incandescent lamps and the other using fluorescent lamps. Ten observers were enlisted and directed to judge the point at which the contrast appeared to be objectionable. The cavity depth was varied until the point of objectionable contrast (for each observer) was reached. The average brightness on the panel was varied from 10 to 1000 footlamberts by varying the cavity depth, lamp spacing, and lamps. The brightness difference between adjacent maximum and minimum values at the objectionable threshold was recorded. The plotted points obtained produced a line of such very slight curvature, that it was more useful to show it as a straight line. The spread between points, however, suggested that two other lines be drawn as shown on Fig. 3. These three lines created four areas or zones *A*, *B*, *C*, and *D*. When the brightness difference between adjacent maximum and minimum values falls in area *A*, the brightness pattern was found to be satisfactory to all observers. Area *B* includes the brightness differences that most observers considered satisfactory but a few considered objectionable. Area *C* includes those brightness differences objectionable to most but not all observers. Brightness differences falling in area *D* were considered objectionable by all observers. The contrast $\frac{B_{max} - B_{min}}{B_{avg}}$* represented by the three lines in Fig. 3, is 0.225 for the lowest, 0.25 for the center one, and 0.275 for the top one. Ratios of $\frac{B_{max}}{B_{min}}$ for these contrasts are respectively 1.254, 1.287, and 1.32. These figures check closely with the figure of 1.3 given by Potter and Meaker[4] but not as well with those reported by the Osram Company[4] which gave values from 1.5 to 2. They are still further from the values of 2.92 and 3.4 reported by Lyon[5] as being satisfactory. Perhaps the explanation for this variation is that the higher figures were obtained by the ratio of highest to lowest brightness while the lower figures were ratios of highest to lowest ***adjacent*** brightness.

Part II — Brightness and Efficiency

The second step was to obtain average brightness and maximum and minimum adjacent brightness values for six variations of lamp height, five different lamp spacings, and four transmittances using

*Although this ratio is not the true definition of contrast, it was found more useful in comparing the results to use average instead of maximum brightness.

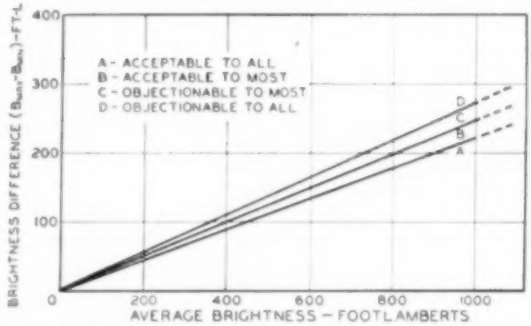

Fig. 3.—Objectionable brightness differences at various average brightness. The test points gave the center line and fell between the two outside lines.

T-12 fluorescent lamps giving approximately 450 lumens per foot.

Table I condenses the important results, and Figs. 4, 5, and 6 show the effects of these variations on efficiency and brightness differences. An analysis of the curves shows the following:

(1) As the ratio S/h increases, the lamp spacing for peak efficiency increases from approximately six inches at a ratio of one, to approximately 15 inches at a ratio of two and the maximum continues over a larger range.

(2) The effect of transmittance on efficiency becomes negligible for larger dimensions.

(3) Test setups with diffusers of lower transmittance reach peak efficiency at greater lamp spacings than those of higher transmittance.

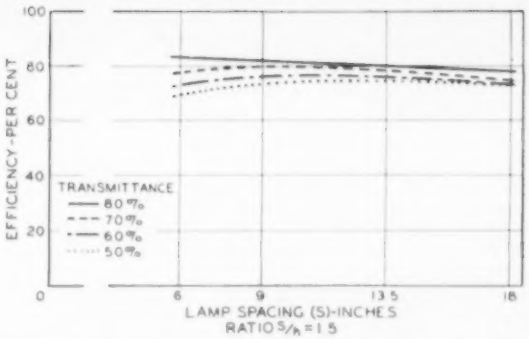

Fig. 5.—Efficiencies when lamp spacing is 1.5 times lamp height.

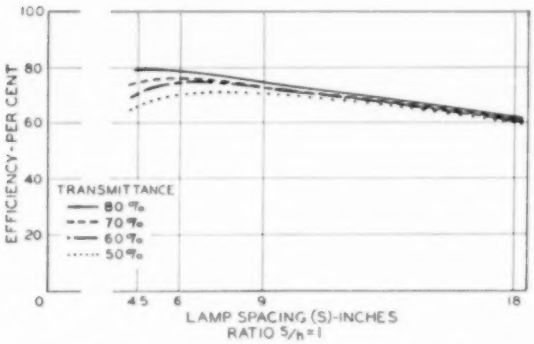

Fig. 4.—Efficiencies when lamp spacing equals lamp height.

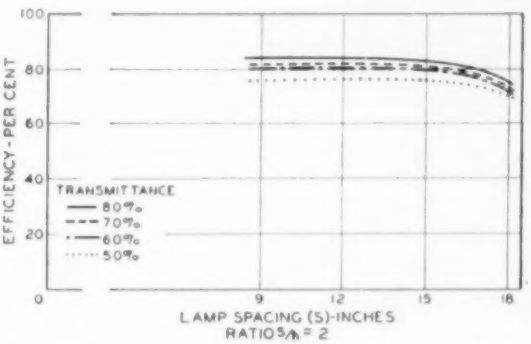

Fig. 6.—Efficiencies when lamp spacing is twice lamp height.

TABLE I.—Efficiency, Average Brightness, Contrast, and Acceptability Zone Values for Various Lamp Height, Lamp Spacing, and Transmission Combinations.

h in.	S in.	Transmission %	Efficiency %	B avg. Ft-L	Contrast	Zone (Fig. 1)	h in.	S in.	Transmission %	Efficiency %	B avg. Ft-L	Contrast	Zone (Fig. 1)
4.5	3	50	62.5	1139	.218	A	9	3	50	60.3	1098	.222	A
		60	67.5	1231	.243	B			60	63.2	1150	.224	A
		70	72.1	1341	.256	C			70	65.6	1197	.219	A
		80	73.8	1347	.278	D			80	67.2	1224	.228	B
	4.5	50	66.2	800	.263	C		6	50	64.4	588	.211	A
		60	70	859	.284	D			60	68.4	624	.270	C
		70	74.8	909	.313	D			70	69.9	637	.264	C
		80	78.8	959	.333	D			80	75.1	685	.279	D
	6	50	69.4	630	.272	C		9	50	70.3	426	.188	A
		60	73.6	672	.297	D			60	72.3	438	.285	D
		70	77.7	707	.327	D			70	72.4	440	.296	D
		80	83.7	764	.346	D			80	74.8	454	.298	D
	9	50	75.2	457	.280	D		13.5	50	73.2	333	.246	B
		60	80.3	488	.295	D			60	76.2	346	.327	D
		70	80.9	492	.342	D			70	76.7	349	.336	D
		80	83	505	.372	D			80	80.3	366	.369	D
6	3	50	63.6	1160	.193	A	12	18	50	70.7	214	.313	D
		60	68.2	1242	.202	A			60	73.5	223	.385	D
		70	69.3	1263	.239	B			70	74.3	225	.436	D
		80	74.7	1363	.235	B			80	77.9	236	.471	D
	6	50	70	638	.232	B	18	6	50	55.2	503	.213	A
		60	74.4	677	.275	C			60	61.3	560	.221	A
		70	76.8	698	.288	D			70	61.9	565	.207	A
		80	78.1	711	.305	D			80	67.1	612	.226	B
	9	50	72.8	442	.290	D		9	50	59.4	361	.167	A
		60	78.1	474	.281	D			60	61	370	.176	A
		70	80.5	488	.283	D			70	62.7	380	.250	B
		80	81.4	494	.291	D			80	62.7	381	.302	D
7.5	15	50	76	347	.300	D		18	50	60.2	182	.192	A
		60	79.5	362	.329	D			60	60.5	184	.299	D
		70	80.5	367	.360	D			70	61.2	186	.323	D
		80	83.5	381	.410	D			80	62.2	188	.345	D

Part III — Interpretation of Parts I and II

The third step was to draw conclusions from the first two. In order to do this, it was necessary to draw another set of curves showing appearance or acceptability for the same parameters as those already tested. These are shown in Figs 7, 8, and 9. The three horizontal lines in the center form four areas, *A*, *B*, *C*, and *D*, which correspond with those in Fig. 3. Thus, in Fig. 7, the lower dotted curve for 50 per cent transmittance, shows at a glance that at a ratio *(S/h)* of one, lamp spacings six and one-half inches or greater will be considered acceptable by everyone since they fall in Zone *A*.

Analyzing Figs. 4 and 7 together shows that for 50 per cent transmittance optimum conditions (considering both luminous efficiency and appearance) prevail at a lamp spacing of about eight inches. For 60 per cent transmittance the optimum lamp spacing would be about nine inches. Fig. 7 alone would show that a transmittance of 70 per cent and over will not be satisfactory at any lamp spacing. The same procedure applied to Figs. 5 and 8, shows that optimum conditions for 50 per cent transmittance at a ratio of 1.5 are obtained at a lamp spacing of about ten inches and that other transmittances will be objectionable in appearance.

In Table I, the last column denotes the area or zone in which each combination of parameters falls. It should be a useful guide to those designing luminous elements.

Some overall conclusions can be drawn from the curves. Efficiency is not significantly affected by transmittance, but it mainly governed by the reflectance of surfaces and the overall dimensions of the cavity. Transmittances over 50 per cent should not be used where the ratio is greater than 1.5.

One thing should be mentioned. Diffusion is not synonymous with transmittance, but the two are usually closely related for a given material. This means that although the above information (based on white #2333 corrugated Plexiglas) will not hold rigorously for all materials, it will be a close approximation for similar material and can be used as a reference by designers — especially when one of the variables is specified and unchangeable.

For example, if it is required to place luminous coffers in a room in which the ceiling cavity is limited to one foot, the following procedure will determine spacings and transmittances for best efficiency and appearance.

First, since the lamps (because of channels and holders) cannot be placed closer than two inches from the ceiling, the maximum lamp height *(h)*

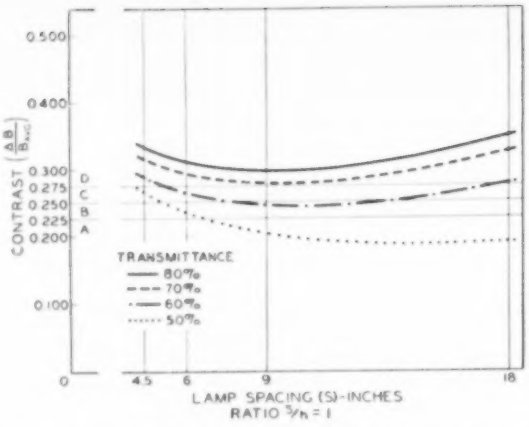

Fig. 7.—Contrast at a ratio *(S/h)* of 1. *A* zone acceptable. *D* zone objectionable. *B*, *C* zones are threshold of acceptability.

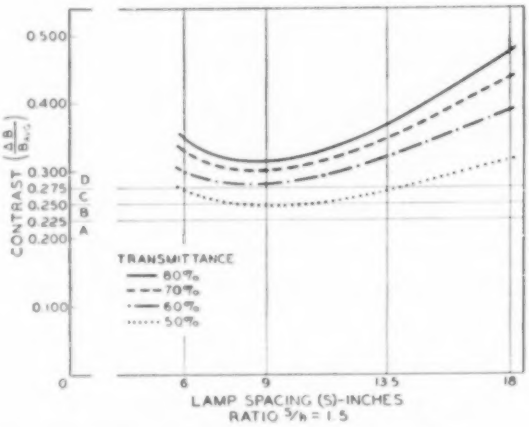

Fig. 8.—Contrast at a ratio *(S/h)* of 1.5. *A* zone acceptable. *D* zone objectionable. *B*, *C* zones are threshold of acceptability.

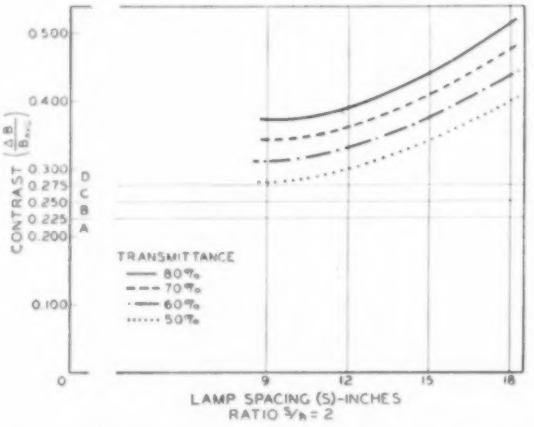

Fig. 9.—Contrast at a ratio *(S/h)* of 2. *A* zone acceptable. *D* zone objectionable. *B*, *C* zones are threshold of acceptability.

will be limited to ten inches. From Figs. 7 and 8, it can be seen that a transmittance of 50 per cent will fall in Zone *A* at a ratio *(S/h)* of one, and in Zone *B* at a ratio of 1.5. Also, a transmittance of 60 per cent will fall in Zone *B* at a ratio of one. Consideration of the brightness desired (or the total output lumens needed) will determine how many T-12 lamps at 450 lumens per foot should be used. From the column of average brightness in Table I, it can be estimated that a ratio of one, will provide about 400 footlamberts on the diffusing element while a ratio of 1.5 will provide about 300. If a brightness of 400 is preferred, the logical choice for transmittance is 50 per cent, since Fig. 4 shows an increase in efficiency of only two per cent from an increase in transmittance from 50 to 60 per cent. Thus, the decision to use 10-inch lamp height, 10-inch spacing, and 50 per cent transmittance can be made with the assurance that acceptable appearance, 70 per cent efficiency (if cavity reflectances are 80 per cent or better), and an average brightness of about 400 footlamberts will result.

The writer is indebted to the Rohm and Haas Company for supplying the plastic elements used in this work, to many of his colleagues at Westinghouse in acting as subjects for the experiment and for their excellent suggestions.

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DISCUSSION

H. A. Williams*: Mr. Haskins is to be complimented on his paper which shows the diligence with which he carried out his experiments. However, I feel that the limited size of the test equipment gave results which, if used to predict the performance of large scale installations, would prove misleading.

From Table I he analyzes his results to show that as the ratio of spacing to lamp height increases the lamp spacing for peak efficiency increases. However, this conclurion was drawn from tube spacings which ranged from three to eighteen inches. In large scale luminous ceiling installations tubes are rarely on 12 inch centers, usually on 18 or 36 inch centers. With such installations, the lamp spacing will not affect efficiency. Mr. Haskins' results, particularly in the case of 50 per cent transmission at a 1 to 1 ratio, showed this peaking of efficiency because in his test set up the size of the fluorescent tube, in relation to the other dimensions, was so great that tube absorption affected efficiency when tubes were on three- to six inch centers. As he continued his experiment and increased the lamp spacing he had to remove tubes from the test box, thereby reducing tube absorption with an apparent increase in efficiency. The drop off from peak efficiency as spacing increased from nine to eighteen inches was the result of the increased depth of the cavity which made the cavity less efficient.

The second conclusion he draws from the test results is that the effect of transmission on efficiency becomes negligible for larger dimensions. Here again, I believe this holds true only for his test conditions. Certainly it is in contradiction to the Moon-Spencer Equation for Plenum Efficiency which states that for an infinitely large room, transmission is directly proportional to plenum efficiency.

$$\text{Plenum Efficiency} = \frac{\left(\begin{array}{c}\text{Transmission of}\\ \text{diffusing material}\end{array}\right)\left(\begin{array}{c}1+\text{plenum}\\ \text{reflectance}\end{array}\right)}{2\left(1-\left(\begin{array}{c}\text{reflectance of}\\ \text{diffusor}\end{array}\right)\left(\begin{array}{c}\text{plenum}\\ \text{reflectance}\end{array}\right)\right)}$$ **

I agree with Mr. Haskins that diffusing material having a transmission of higher than 50 per cent should not be used if the spacing to tube height exceeds the 1.5 ratio providing complete brightness uniformity is required. However, there are many of us who feel that the lighting engineer has been too concerned with uniform brightness. While uniform brightness may be necessary for certain installations, such as power station control rooms or automotive design studios; for most installations some brightness variation is attractive and is to be desired.

If some brightness varintion is acceptable to the customer, the lighting engineer can use diffusing material of higher transmission which, with an efficient shallow plenum will give a highly efficient installation.

R. T. Dorsey*: Mr. Haskins has investigated an important area in which we need data on new materials and present-day light sources to supplement the earlier work of Potter and Meaker and others, in 1931.

The concept of zones representing degrees of acceptability of brightness variation should prove helpful not only in designing for optimum conditions but as an aid in evaluating compromises that may be forced by physical limitations of a given installation.

Referring to Figs. 7, 8, and 9, and to Table I, one finds that most of the data fall in zones C and D. We hope that the data will be expanded to include more combinations which will fall in zones A and B where contrasts are acceptable. It might be pointed out that where a pattern is superimposed on the luminous panel, higher spacing ratios are usually acceptable.

A question on calculation of efficiency. As stated in the paper "Transmitted flux was calculated by multiplying the average brightness of the diffuser in footlamberts by its area in square feet." This, of course, must assume perfect diffusion. If the flux distribution departs from the cosine this relation no longer holds perfectly. In many other investigations of a similar nature, substantial departures from the theoretical cosine distributions were experienced. This could have a noticeable effect on the calculated efficiency. How was this taken into account?

The average brightness, normal to the luminous panel, is useful for signs and other vertical luminous elements. For

*Rohm & Haas Co., Philadelphia, Pa.

**"Interflections in Coupled Enclosures," Moon and Spencer, *Journal of the Franklin Institute*, August 1950, page 151.
*General Electric Co., Cleveland, Ohio.

general illumination from ceiling panels, the brightness at some angle from the normal, would be more useful. This may be considerably lower than the values given in Table I. In many installations, it may be desirable to use lamps whose output is different from the T12 fluorescent lamps used for the test. Furthermore, the same S/h ratios will not always be used. A more universal basis for the brightnesses in Table I would be to convert them to average brightness per 100 lumens, per square foot, generated by the lamps within the box, as has been done in previous similar investigations, such as the louverall study, by Potter and Oetting (I.E., Vol. XLIV, Nos. 1 and 6, January and June, 1949).

The tests are based on a cavity reflectance of 80 per cent. While this is an easily obtainable value initially, the maintained value under service conditions will often be lower. It would be helpful to know how lower reflectances will affect efficiency and contrasts.

M. E. HASKINS, JR.*: Messrs. Williams' and Dorsey's remarks are much appreciated since they bring out several points which could not be covered in the paper because of space limitations. It seems the best procedure to comment on each discussion separately and only on points that can benefit from further clarification.

Mr. Williams' objection that the test results, if used to predict the performance of large scale installations, would prove misleading is quite valid. The data were not intended for this purpose and should not be extrapolated. He points out that efficiencies of larger cavities would be higher and gives an excellent explanation of why those obtained in this work are lower. However, the Moon-Spencer Equation for Plenum Efficiency to which he refers is not really applicable for the type of cavity investigated since it was derived for plenums of infinite size and the effect of walls is neglected. Furthrmore, according to Fig. 6 in "Luminous Ceiling Lighting," Moon and Spencer, I.E., August 1949, page 468, plenum efficiency is not directly proportional to transmittance. This is not meant to imply that the dimensions of the plenum have a greater effect on efficiency than transmittance. As a matter of fact, a method for comparing their relative effects was looked for but not found. What is intended to bring out is that the dimensions do affect efficiency — and more than ordinarily believed. In view of this, the efficiencies obtained in the tests are about what should be expected.

As to whether complete brightness uniformity is or should be the optimum condition for luminous elements, I would never insist that it is. My decision to define it as such was admittedly arbitrary but it seemed to be the most objective way to approach the problem. For those who, like Mr. Williams, prefer some variation, it will be a simple matter for them to determine what contrast *they* consider optimum and add that to the contrast found in this work to be objectionable.

Mr. Dorsey has pointed out some difficulties and limitations and has offered helpful criticism. As he mentions, most of the data fall in zones C and D. They were included because some designers share the same opinion as Mr. Williams, namely, that a little brightness variation is desirable. For them zone C and even part of zone D may be acceptable. The data offer enough leeway for new zones to be individually determined.

Mr. Dorsey wants to know how the flux distribution departs from the cosine. Since the area subtended by the meter was great enough to include significant curvature of the plastic, no definite effort was made to determine if the flux distribution was perfectly diffuse. Some brightness readings at given points were taken at various angles and found to be about the same. Therefore, it seemed a safe conclusion to assume a cosine distribution.

In view of this, brightness measurements at other angles than normal should not be significantly lower than the values given in Table I, as Mr. Dorsey states.

Mr. Dorsey suggests that the data in Table I should have been presented on a per 100 lumens, per square foot basis in order to permit other than T-12 fluorescent lamps to be evaluated. The data are really applicable as they appear although the table should have been captioned as applying only to fluorescent lamps having an output of 450 lumens per foot. To use the data for fluorescent lamps having any other output it is only necessary to multiply the brightness given in the table by the lumens per foot of the lamps used and divide by 450.

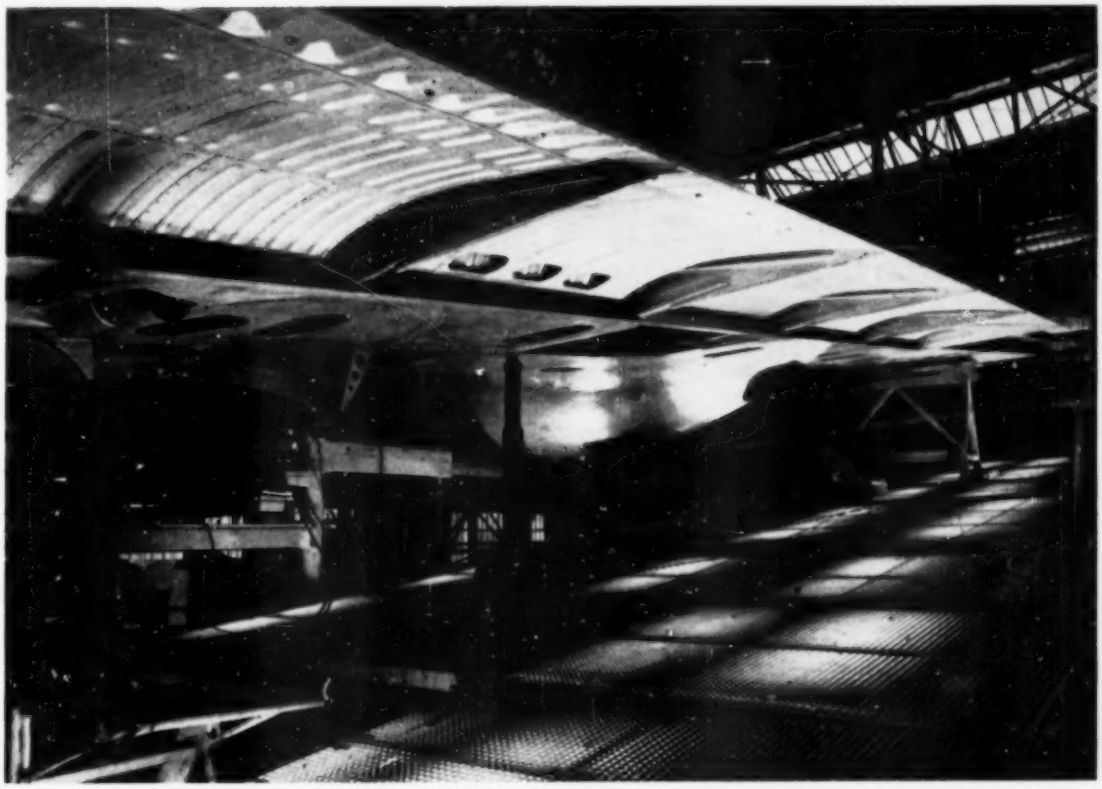
Mr. Dorsey is correct in stating that the cavity reflectance will materially affect efficiency and contrasts. Limitation of time prevented introduction of another variable at this time.

*Author.

Back Issues of I.E.S. Transactions Needed

Five issues of the "Transactions of the Illuminating Engineering Society" are missing from the library of the late George G. Cousins, which at his wish was presented to the Engineering Library of Queen's University. The assistance of I.E.S. members in completing this collection has been requested.

The missing issues are: July 1920 (Vol. XV, No. 7); July 1923 (Vol. XVIII, No. 7); May 1930 (Vol. XXV, No. 5); December 1934 (Vol. XXIX, No. 10), and June 1936 (Vol. XXXI, No. 6). Anyone who wishes to donate these copies to the library should get in touch with Mr. Frank Reed, c/o John C. Virden, Ltd., 19 Curity Avenue, Toronto, Ontario, or with Professor H. S. Pollock, Queen's University, Kingston, Ontario.



INSTALLATION AT ORLY AIRPORT, PARIS, FRANCE.

Lighting for Airplane Repair

LIGHTING OBJECTIVE: To illuminate the underside of an airplane in a large hangar used for repairs.

GENERAL INFORMATION: Overhead general lighting in an airplane repair area is not adequate for repairs beneath the wings. Portable supplementary lamps are usually employed for such work, but their light output is low and they are often sources of glare. The platform shown above was especially built to minimize time lost in erecting special scaffolding for major airplane repairs. Constellation planes are overhauled here after 1200 to 1500 flying hours (depending on whether they are used in cool or tropical regions).

The platform measures 128 x 18½ feet; its maximum height is 14¾ feet. The plane to be repaired is moved by a small tractor into place between the fixed parts of the platform. Then the movable elements, mounted on rubber wheels, are moved into place, after which the wheels are withdrawn and the movable sections of platform rest on the floor. The plane is supported on three jacks, and the platform is covered with a metallic grid capable of supporting heavy loads.

INSTALLATION: Forty-two wide-distribution fluorescent luminaires are arranged 11.8 inches beneath the mesh platform as shown in Figure 4. The reflectors are painted matte white inside and light gray on the outside. Each contains two 40-watt white instant-start lamps operated on a lead-lag ballast. The reflector is covered by armored glass and the assembly is vapor- and water-proof. Within the luminaire, between the lamps and the armored glass, is a highly diffusing sheet of Plexiglas. The mesh platform provides external shielding. The luminaires can be tipped to any desired angle.

(over)

A.I.A. File No. 31-f

Figure 2. General view of hangar and work platform.

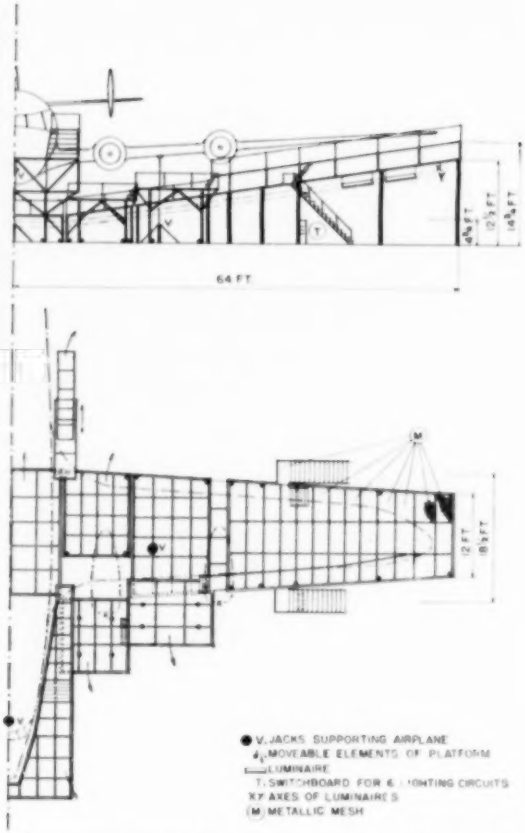


Figure 3. (left) Close-up showing luminaires, metallic grid flooring, and underside of wing.

Figure 4. (above) Elevation and plan views showing luminaire and platform locations with respect to airplane.

The resultant average illumination on the underside of the wing is 12 footcandles maintained. At points of particular interest where precise, delicate or prolonged work is likely, the illumination is greater because the luminaires are spaced closer together.

There are six separately switched electrical circuits. The power factor is 0.95, and there is a magnetic shunt in each luminaire which compensates for the negative characteristic of the lamps. Special equipment is provided to limit the emission of frequencies which might interfere with the airport radio equipment (instrument landing apparatus, etc.).

The platform was designed by Mr. Garaud, Engineer of Orly Airport; electrical installation by Mr. Rosen of the Societe Industrielle de Participation; and lighting by Mr. Jean Despres, Engineer of the Compagnie des Lampes, 29 rue de Lisbonne, Paris, France.

Lighting data submitted by Jean Despres, Compagnie des Lampes, as one solution to a lighting problem and to aid in the design of similar installations.

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Interflectance Tables from Conventional Photometric Data

By LESLIE E. INNIS

THE BASIC REASON that the interflection method has not been more widely applied by illuminating engineers is that manufacturers have not made available the necessary data. The reason for this is felt to be the laborious and complicated procedure involved in obtaining tables of coefficients of utilization and other data based on interflection theory and pertaining to specific commercial luminaires. It is the purpose of this paper to describe a simplified procedure developed by Moon and Spencer and by making use of certain data obtained from this procedure to construct tables applicable to some of the more common types of luminaires from which manufacturers can obtain coefficients of utilization merely by multiplying tabulated values by the given luminaire efficiency.

Background

The interflection method[1] was the first major lighting calculation method to be introduced since the early work of Harrison and Anderson. This method, if carried out as envisioned by Moon and Spencer, would have the following advantages.

1. It allows the predetermination of not only coefficients of utilization, but also of average wall, ceiling and floor brightness.
2. Solutions are provided for reflectance values of wall, ceiling and floor found in present day practice.
3. Being of a theoretical nature, it invites the analysis which leads to a deeper understanding of the many variables involved in room lighting.
4. It is applicable to large area luminaires and overall lighting systems such as the luminous ceiling.
5. It verifies mathematically and employs Hisano's experimentally determined concept of room index (k_r).

This last point is a keystone of the method since it contributes to the accuracy of results by "custom fitting" a room. The same can not be said of the presently used letter indices where accuracy is deliberately sacrificed for simplicity of usage. Since Allphin[2] has published an ingenious chart for determining numerical indices by visual means once the room dimensions are known, such a sacrifice would no longer seem justifiable. Hisano's numerical index is defined by

$$k_r = \frac{h\,(l + w)}{2\,l\,w} \qquad \text{Equation 1}$$

where h = ceiling height
l = room length
w = room width

The approach to the coefficient of utilization in the interflection method is made via tables of interflectance values or as they are sometimes called utilization factors (not to be confused with the coefficient of utilization). When interflectance is known, the coefficient of utilization can be calculated from the simple relationship

$$k_u = f\,(Eff) \qquad \text{Equation 2}$$

where k_u = coefficient of utilization
f = interflectance
Eff = luminaire efficiency

The advantage of dealing with the concept of interflectance is that it allows a more universal usage. For example, an industrial luminaire and a troffer having the same relative distribution pattern would have the same value of interflectance although their efficiencies and thus their coefficients of utilization might be widely different. In this case, if interflectance were known, coefficients of utilization could be determined for either luminaire by simple multiplication.

Moon-Spencer tables of interflectance have been published[1] for three fundamental patterns of light distribution. They are as follows:

1. Wall lighting — all luminous flux from the luminaire is directly incident upon the walls.
2. Ceiling lighting — all luminous flux from the luminaire is directly incident upon the ceiling.
3. Floor lighting — all luminous flux from the luminaire is directly incident upon the floor.

Unfortunately, for fixture manufacturers who desire to release comprehensive data for field use, most luminaires do not direct all their flux to any one of the major room surfaces. For these units use had to be made of the principle of superposition which may be expressed mathematically as follows:

$$f = f_1\left(\frac{F_1}{F_D}\right) + f_2\left(\frac{F_2}{F_D}\right) + f_3\left(\frac{F_3}{F_D}\right) \qquad \text{Equation 3}$$

where f = interflectance of luminaire

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 14-17, 1953, New York, N. Y. AUTHOR: Sylvania Electric Products Inc., Salem, Mass.

f_1 = interflectance from wall lighting tables
f_2 = interflectance from ceiling lighting tables
f_3 = interflectance from floor lighting tables
F_1 = luminaire output directly to walls (lumens)
F_2 = luminaire output directly to ceiling (lumens)
F_3 = luminaire output directly to floor (lumens)
F_D = total luminaire output (lumens)

The problem facing the manufacturer was then essentially to determine the flux ratios, $\frac{F_i}{F_D}$, where $i = 1, 2, 3$, for specific luminaires.

A method of determining the flux ratios has been described in the literature.[3] Disadvantages of this method were threefold.

1. Since it did not make use of conventional photometric data, new photometric techniques were required which were more laborious and time consuming.
2. An engineering layout was required for each value of room index (k_r) to be tabulated. Each layout in turn involved a discreet number of luminaires and an arduous summation process was required to determine the flux ratios as a function of k_r.
3. Values of floor interflectance as used in Equation 3 are based on the assumption that the flux reaching the floor is equal to that passing through the principal surface (an imaginary surface at a distance equal to one-quarter of the ceiling height above the floor). While such an assumption is valid for a very concentrating distribution, the flux lost by wall absorption between the principal surface and the floor for a wide distribution pattern may be of such a magnitude that the flux to the floor is considerably less than that to the principal surface. The result is that values obtained through the use of Equation 3 are apt to predict levels of illumination which are low.

Simplified Procedure

Moon and Spencer,[4] recognizing the difficulties involved have developed a simplified procedure of determining these flux ratios, $\frac{F_i}{F_D}$. This method eliminates the above disadvantages by employing conventional photometric data, replacing the time consuming summation by a simple integration and differentiating between flux to principal plane and flux to floor.

The first step in this method was to select a number of distributions which were felt to cover in a fairly representative way, the range of curves obtained by actual luminaires. Six definite curves were selected, three mounting heights being employed for two of them so that the total number of arrangements is ten. These curves shown in Fig. 1 are as follows:

Distribution No. 1 — Uniformly diffusing globes,
$I(\theta) = I(0)$, θ ranges from 0 to 180°,
$hm = \frac{3}{4}\,h$.

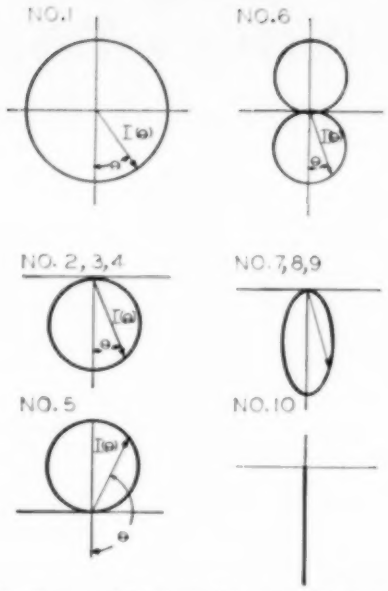

Figure 1. Representative candlepower distribution patterns chosen by Moon and Spencer for study.

Distribution No. 2
Direct lighting, spread distribution,
$I(\theta) = I(0) \cos\theta$, θ ranges from 0 to 90°,
$hm = h$.

Distribution No. 3
Same as No. 2 except $hm = \frac{3}{4}\,h$.

Distribution No. 4
Same as No. 2 except $hm = \frac{1}{2}\,h$.

Distribution No. 5 — Indirect lighting,
$I(\theta) = -I(0) \cos\theta$, θ ranges from 90 to 180°,
$hm = \frac{3}{4}\,h$.

Distribution No. 6 — Direct-Indirect
$I(\theta) = I(0) \mid \cos\theta \mid$, θ ranges from 0 to 180°,
$hm = \frac{3}{4}\,h$.

Distribution No. 7
Direct lighting, narrow distribution,
$I(\theta) = I(0) \cos^3\theta$, θ ranges from 0 to 90°,
$hm = h$.

Distribution No. 8
Same as No. 7 except $hm = \frac{3}{4}\,h$.

Distribution No. 9
Same as No. 7 except $hm = \frac{1}{2}\,h$.

Distribution No. 10 — Floor lighting
(very narrow beam, no lumens to the walls),
any hm.

All distributions are symmetrical about a vertical axis, θ is the angle between a given ray and the vertical axis, $\theta = 0°$ occurring at nadir and $I(\theta)$ is the luminous intensity or candlepower in the direction θ. The mounting height is denoted by hm, the

ceiling height by h both distances being measured from the floor. The symbol $|\cos\theta|$ means use only the magnitude of the cosine, ignore the sign.

As a next step square rooms (as usually used) were replaced by infinitely long rooms. When this is done Equation 1 reduces to

$$k_r = \frac{h}{2w} \qquad \text{Equation 4}$$

This step allows a three dimensional problem to be reduced to one of two dimensions. Then for each of the distributions shown in Fig. 1, a discreet system of luminaires was replaced by a continuous luminous element, each small part of which had the same distribution as the particular pattern under study. When this was done it became possible to establish integral equations, the solution of which yielded the desired flux ratios.

To avoid any error inherent in Equation 3, the principle of superposition is applied through the use of the equation

Equation 5

$$f = f_1\left(\frac{F_1}{F_D}\right) + f_2\left(\frac{F_2}{F_D}\right) + (f_3 - 1)\left(\frac{F_3}{F_D}\right) + \left(\frac{F_{Dir}}{F_D}\right)$$

where F_{Dir} = the luminaire output directly to the principal surface (lumens).

This direct ratio $\frac{F_{Dir}}{F_D}$ was obtained as a special solution of the same integral equation used to obtain the floor ratio, $\frac{F_3}{F_D}$.

A more detailed discussion of the theory and mathematics involved in this method of determining the flux ratios will not be given here because it is not desired to place a barrier of complex mathematics between the manufacturer of lighting equipment and the resulting interflectance tables. For the inquisitive reader the subject has been more than adequately covered in the original source. Here, the flux ratios as given by this method will be used to construct interflectance tables for certain commonly encountered distributions such as Distributions Nos. 2, 3, and 5 (See Fig. 1). In addition, the possibilities of extending these tables to other types of distributions will be explored.

Construction of Tables

Distribution No. 2 (Fig. 1) is one of the more common types met with. It applies not only to fluorescent industrials, but also to certain types of troffers. Flux ratios for this distribution are given in Table A. Using these ratios, interflectance values are computed as shown in Example 1.

TABLE A.—Calculated Flux Ratios for a Totally Direct Distribution Pattern (See Distribution No. 2, Fig. 1). Flux to the Ceiling (F_2) Equals Zero.

k_r	$\frac{F_1}{F_D}$	$\frac{F_2}{F_D}$	$\frac{F_{Direct}}{F_D}$
0.0	0.0	1.000	1.000
0.1	0.181	0.819	0.882
0.2	0.323	0.677	0.774
0.3	0.434	0.566	0.681
0.4	0.519	0.481	0.599
0.5	0.586	0.414	0.527
0.6	0.638	0.362	0.467
0.7	0.680	0.320	0.418
0.8	0.713	0.287	0.376
0.9	0.741	0.259	0.342
1.0	0.764	0.236	0.313

Example 1

For Distribution No. 2

$k_r = 0.5$

wall reflectance = 0.50

ceiling reflectance = 0.80

floor reflectance = 0.30

we find from the basic interflectance tables

$f_1 = 0.295$

$f_3 = 1.115$

From Table A

$$\frac{F_1}{F_D} = 0.586,\ \frac{F_2}{F_D} = 0,\ \frac{F_3}{F_D} = 0.414,\ \frac{F_{Dir}}{F_D} = 0.527$$

From Equation 5

$$f = 0.295\ (0.586) + 0.115\ (0.414) + 0.527$$
$$= 0.748$$

Values for Distribution No. 2 are tabulated as Interflectance Table No. 1.

Interflectance Table No. 5 which pertains to luminaires having the same distribution as above but suspended one-quarter of the ceiling height below the ceiling was formed in the same manner using the flux ratios applicable to Distribution No. 3.

If the direct flux ratios given in Table A are compared with those as given by Moon and Spencer, they will be found to be slightly higher. Moon and Spencer have shown in the original paper that the procedure of replacing a discreet number of luminaires by a continuous luminous element can lead to the floor flux ratios being low by as much as 6 per cent. This in itself is not too important since a low floor flux ratio means that the wall ratio will be high by a compensating amount. The result is that any error inherent in the final interflectance is usually considerably less than the flux ratio error. However, the same equation is used to obtain both floor ratio and direct ratios and any error in the direct ratio will show up in the final value as an error of approximately the same magnitude. In checking these calculated values against direct

ratios determined experimentally, the former were found to be low by the same magnitude as predicted by Moon and Spencer and therefore have been corrected upward to bring them into agreement with the experimentally determined values.

The construction of a table of interflectance for the indirect distribution (No. 5, Fig. 1) is considerably simplified by the absence of floor and direct flux ratios. Interflectance Table No. 15 gives values for a distribution of this type.

Interflectance Tables for Other Distributions

Many pendent mounted luminaires have distributions similar to No. 6 (Fig. 1) but having circles of unequal size. By employing a parameter P, defined as the downward component of the usual C.I.E. distribution, it is possible to combine Distributions Nos. 3 and 5 to provide interflectance tables for these luminaires. Using this parameter we have

$$f_P = P\,(f_{\text{No. 3}}) + (1 - P)\,f_{\text{No. 5}} \qquad \text{Equation 6}$$

where f_P = interflectance of a luminaire having a C.I.E. distribution equal to $\frac{1-P}{P}$,

$f_{\text{No. 3}}$ = interflectance produced by Distribution No. 3,

$f_{\text{No. 5}}$ = interflectance produced by Distribution No. 5.

Interflectance Tables Nos. 6-14 follow from Equation 6 when P is varied from 0.9 to 0.1 in steps of 0.1. Fig. 2 shows interflectance curves of the eleven distributions so formed for a given set of reflectances. Additional tables could be provided in steps of P equal 0.05 by simple interpolation. If such tables are formed, it can be seen from Fig. 2 that luminaires having other values of P could be fitted to the nearest available table without appreciable loss of accuracy. Coefficients of utilization would then be obtained by multiplying all values in the proper interflectance table by the luminaire efficiency.

When luminaires, designed primarily for use as suspended units, are surface mounted their distributional characteristics are so drastically affected that additional photometric data are required. To obtain tables for units of this type Distribution No. 2 has been combined with Distribution No. 5. It must, of course, be recognized that such a procedure is not rigorously correct since

a. Distribution No. 5 pertains not to a surface mounting but to a suspension length equal to one-quarter of the ceiling height.

b. The distribution of such a surface-mounted unit is not even similar to Distribution No. 5.

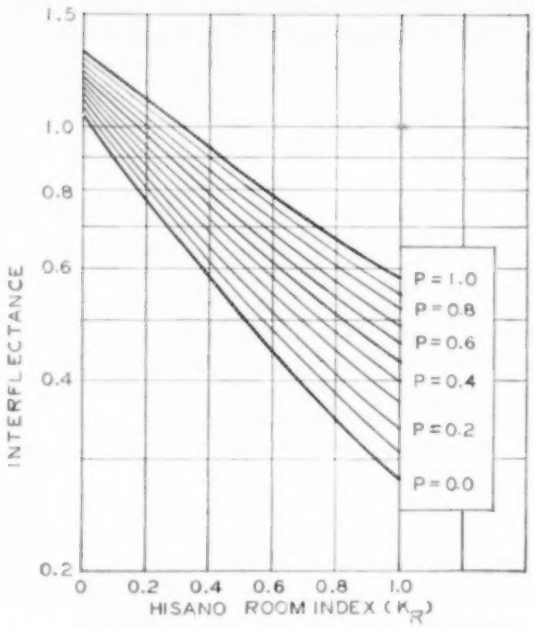

Figure 2. Interflectance curves for eleven different distribution patterns. These curves are obtained by making use of a parameter, P, to combine two major distributions, direct (No. 3, Fig. 1) and indirect (No. 5, Fig. 1). P is defined as the downward component as given in the usual C.I.E. distribution. Values are shown for the case where wall reflectance = 0.50, ceiling reflectance = 0.80, and floor reflectance = 0.30.

Because the distribution in the upper hemisphere is relatively insensitive to change and since the upward component with luminaires of this type is usually small, it is felt that any inherent error will be so small as to be within the limits of accuracy required for engineering practice. Tables for such surface-mounted luminaires are included as Interflectance Tables Nos. 2, 3 and 4.

Effect of Mounting Height for Direct and Semi-Direct Luminaires

A comparison of Interflectance Tables Nos. 1 and 5 will indicate that for most rooms, interflectance is appreciably greater for the direct luminaire with a suspension length equal to one-quarter of the ceiling height than for the same luminaire when surface mounted. This poses the question of how to obtain the interflectance at other suspensions. One method that is suggested by its inherent ease of application is to use Table 1 for all values of hm but to adjust the Hisano room index (k_r) by the equation.

$$k_r' = k_r \frac{hm}{h} \text{ F} \qquad \text{Equation 7}$$

where k_r = Hisano index as determined by room

dimensions

k_r' = adjusted index

F = a proportionality

By applying Equation 7 to Table 1 for the case where $hm = \frac{3}{4}\,h$, values of F were found to range from 0.92 to 1.06. If a value of unity is assigned to F, the maximum error for the critical case of a cubical room having a wall reflectance of 0.10 is found to be less than 5 per cent. For higher values of wall reflectance and for larger rooms this error is greatly reduced. Caution should be exercised, however, for values of hm less than $0.7\,h$ since there is evidence of a rapid departure of the factor F from units in the region $hm = 0.7\,h$ to $0.5\,h$. Spot calculations indicate that F is approximately 0.80 for a suspension length equal to half of the ceiling height. It is interesting to note that such a suspension would call for a relatively high ceiling. This in turn would probably result in the principal surface being located considerably more than 2 feet 6 inches above the floor. Any correction incorporated into the factor F to compensate for this would tend to move its value toward unity. Sufficient data are not available to do more than speculate at this time but a need is clearly indicated for an investigation of the effect of varying the height of the principal plane over relatively large distances.

For luminaires having downward components of 90 per cent — 70 per cent interflectance for non-tabulated suspensions may be obtained in the same manner as above.

Comparison of Results

For the sake of clarity in the following discussion interflectance values as given in Tables 1 to 15 will be referred to as calculated values, those obtained by the older procedure of inserting experimentally determined flux ratios, $\frac{F_A}{F_D}$, into Equation 3 as measured values.

Fig. 3 compares calculated interflectance (Table 1) with values obtained by both the Harrison-Anderson and the Jones-Neidhart[5] methods for a surface-mounted fluorescent industrial luminaire of the R.L.M. type whose distribution is as given in Fig. 4. Calculated and Jones-Neidhart values are in good agreement; the Harrison-Anderson values appear to be slightly low for larger rooms, somewhat higher for smaller rooms.

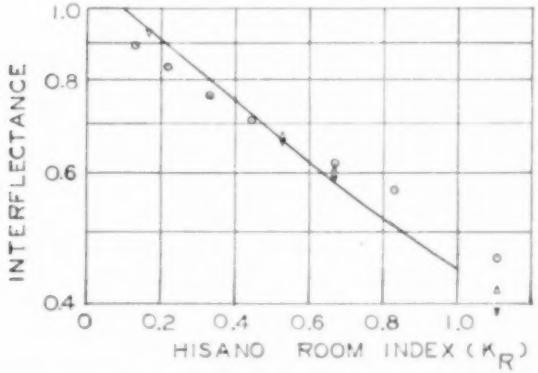

Figure 3. Calculated interflectance for a totally direct industrial luminaire. (For distribution pattern see Fig. 4.) Wall reflectance = 0.50, ceiling reflectance = 0.50, floor reflectance = 0.14. ○ = values as obtained by Harrison-Anderson method. △ = values as obtained by Jones-Neidhart method when spacing to mounting height ratio is 1.0. ▽ = values obtained by Jones-Neidhart when spacing to mounting height ratio = 0.4.

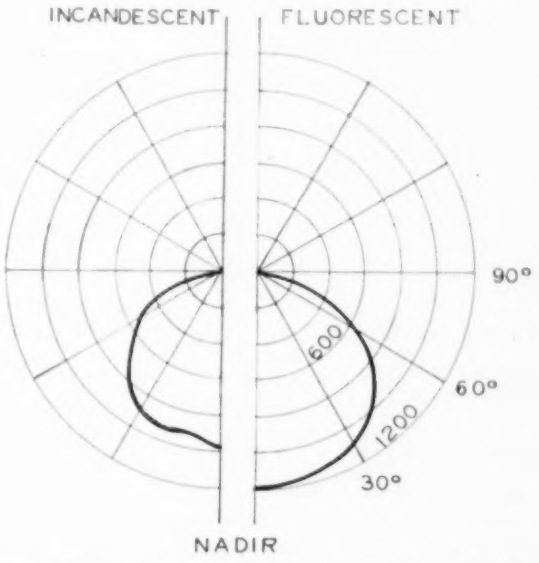

Figure 4. Candlepower distribution patterns for two typical totally direct luminaires, one incandescent, the other fluorescent. Interflectance values are found to be the same for both patterns.

Fig. 4 also gives the distribution of a similar incandescent luminaire. Interflectance is found to be the same for both luminaires when determined by the Harrison-Anderson method. This is also true for the Jones-Neidhart method. It seems evident therefore that Table 1 or Table 5 could be applied to either distribution curve depending on the type of mounting without appreciable loss of accuracy.

Allphin and Spencer[6] have measured interflectance by the experimental method for a pendent mounted, louver bottom, open top fluorescent unit whose distribution is given in Fig. 5. This method made use of Equation 3 which, as has been pointed out earlier, leads to pessimistic results. When experimental values are corrected to compensate for the effect of the flux absorbed by that portion of

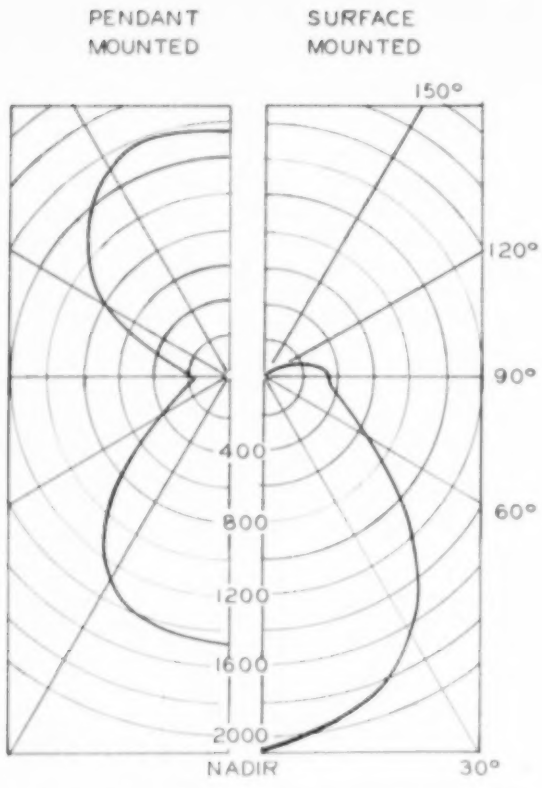

Figure 5. Distribution curves for a typical two-lamp, louver bottom, plastic side, open top fluorescent luminaire. Shielding is 25 x 35°. When pendent mounted the C.I.E. distribution is 57 per cent upward, 43 per cent downward. When surface mounted, the C.I.E. distribution is 16 per cent upward, 84 per cent downward.

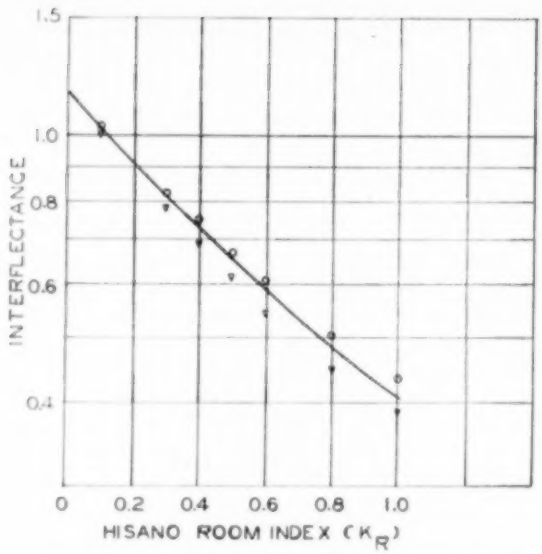

Figure 6. Calculated interflectance for the pendent mounted luminaire whose distribution is shown in Fig. 5, $P = 0.43$. Wall reflectance = 0.50, ceiling reflectance = 0.80, floor reflectance = 0.30. ▽ = values obtained by earlier procedure of determining flux ratios experimentally. No correction has been made for the use of Equation 3. ⊙ = values obtained by earlier procedure when correction is made for the flux absorbed by the wall between principal surface and floor.

the walls lying between the principal surface and the floor, they are found to be in close agreement with those as calculated, the latter being on the average of 3 per cent lower. In Fig. 6 measured and calculated interflectance are compared.

The distribution of the same luminaire when surface mounted is also shown in Fig. 5 while measured and calculated interflectances are compared in Table B. Here the same agreement is evidenced as mentioned above. Maximum difference for both occurs in the case of the cubical room ($k_r = 1.0$) and amounts to approximately 7 per cent.

TABLE B. — Interflectance Values as Obtained by Simplified Procedure and by Earlier Experimental Procedure.
Values are given for a surface mounted, louver bottom, plastic side, two-lamp fluorescent fixture. (For distribution pattern see Fig. 5.) Wall reflectance = 0.50, ceiling reflectance = 0.80, floor reflectance = 0.30.

k_r	Measured Interflectance		Calculated Interflectance
	Uncorrected for Use of Equation 3	Corrected for Use of Equation 3	
0.1	1.092	1.132	1.130
0.3	0.816	0.897	0.876
0.5	0.618	0.704	0.712
0.7	0.491	0.571	0.580
1.0	0.402	0.469	0.442

Additional data are available[3] for a luminous indirect luminaire having a C.I.E. distribution of 92 per cent up, 8 per cent down. Distribution curves in both upper and lower hemispheres for this unit closely approximate circles. Once again agreement is good for values of k_r from 0.0 to 0.7, the calculated values being of the order of 3 per cent lower. For the critical case the cubical room ($k_r = 1.0$) the difference increases in such a manner that the calculated interflectance is of the order of 8 per cent low (Fig. 7). The fact that maximum difference occurs when k_r has a value of unity indicates that the difference may be due to the practice of replacing a discreet number of luminaires by a continuous luminous element and perhaps indicates the need for additional study of the cubical room.

Coefficients of utilization based on the interflection method[2] have been published for another luminous indirect having the same type of distribution. Coefficients obtained by multiplying calculated interflectance by luminaire efficiency again agree in

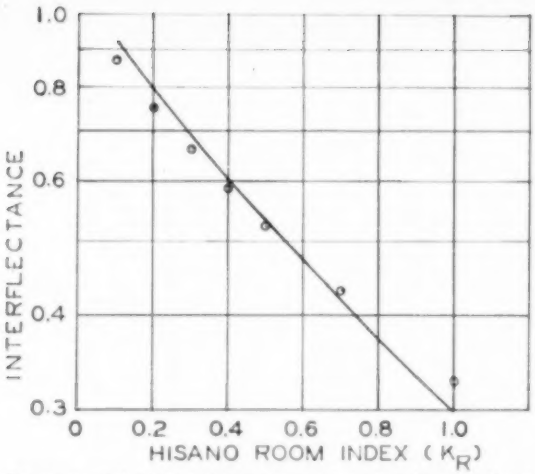

Figure 7. Calculated interflectance for a luminous-indirect luminaire having a C.I.E. distribution of 92 per cent up, 8 per cent down. Wall reflectance = 0.50, ceiling reflectance = 0.80, floor reflectance = 0.30. ⊙ = values obtained by earlier procedure of obtaining flux ratios experimentally. Correction has been made to compensate for the flux absorbed by the wall between principal surface and floor.

the manner described above. These published data have been reported to agree well with field measurements.[8]

In view of these comparisons it seems safe to say that Tables I-15 can be used to provide coefficients of utilization with an accuracy well within the tolerances demanded by engineering practice.

Method of Determining Coefficients of Utilization

Conventional photometry provides the average distribution curve, the C.I.E. distribution and the luminaire efficiency. Coefficients may then be obtained by the manufacturer as follows:

Step 1. — Plot average distribution curve and determine whether Tables 1-15 are applicable.

Step 2. — From C.I.E. distribution select appropriate table.

Step 3. — Multiply values in this table by luminaire efficiency.

While steps 2 and 3 are self-explanatory, a brief discussion of step 1 may be necessary.

In considering the distribution curve in the lower hemisphere it should be noticed that the allowable deviation from the idealized pattern depends on the percentage of the total luminaire output falling in this hemisphere.

For example, considerably more deviation may be tolerated for a luminous-indirect than for a direct type. Figs. 4 and 5 illustrate variations from the idealized conditions that result in negligible error.

In the upper hemisphere a greater tolerance is allowable than in the lower due to the lack of direct flux to the principal surface. In proof of this, interflectance may be determined from available data[9] for the three different indirect distributions shown in Fig. 8. These values are found to be the same for all three patterns.

Figure 8. Three different totally indirect distributions, all of which have the same interflectance.

In general it seems logical to conclude that Tables 1-15 will be applicable to most luminaires having the so-called "wide spread" distributions.

Interflectance Tables for More Concentrating Distributions

While time has not allowed for the construction of tables for some of the other distributions shown in Fig. 1, such tables can be developed in the same manner as described above. Since Distribution No. 8 is typical of many luminaires which have a narrow distribution pattern in the lower hemisphere, it would seem that interflectance tables for a distribution of this type would be particularly useful.

It is also possible to construct tables for distribution patterns other than those shown in Fig. 1 by utilizing other powers of the cos θ. This suggests the possibility of eventually establishing interflectance tables for all luminaires, however, further work will be necessary in order to determine whether such a possibility can become a reality.

Summary

1. A simplified procedure, developed by Moon and Spencer, for obtaining the flux ratios, $\frac{F_i}{F_D}$, necessary for the construction of interflectance tables has been outlined.
2. Using these flux ratios, interflectance tables have been developed for two commonly used wide spread distributions, the totally direct and the totally indirect.
3. By the use of a parameter, P, these major distributions have been combined to provide interflectance tables for many other types of luminaires.

(Text continued on page 609)

C.I.E. Classification: Direct

Pattern of Distribution Curve { Upper Hemisphere — Lower Hemisphere #2

C.I.E. Distribution: Upward — 0
Downward — 100

Mounting Details: $\frac{h_m}{h} = 1$ (Surface)

k_r	Ceiling Reflectance 0.80				0.70			0.50		
	Wall Reflectance				Wall Reflectance			Wall Reflectance		
	0.80	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
FLOOR REFLECTANCE = 0.10										
0	1.087	1.087	1.087	1.087	1.075	1.075	1.075	1.053	1.053	1.053
0.1	1.076	1.010	.977	.946	.596	.967	.938	.973	.948	.923
0.2	1.025	.926	.875	.825	.915	.862	.820	.895	.850	.811
0.3	.988	.849	.780	.722	.838	.773	.719	.814	.759	.712
0.4	.934	.772	.696	.633	.764	.649	.633	.743	.677	.628
0.5	.888	.702	.620	.558	.691	.615	.556	.671	.605	.553
0.6	.841	.642	.553	.496	.628	.549	.492	.611	.543	.489
0.7	.796	.585	.501	.443	.577	.499	.443	.560	.492	.440
0.8	.756	.539	.458	.399	.530	.454	.399	.516	.450	.399
0.9	.719	.495	.419	.367	.488	.417	.365	.477	.413	.365
1.0	.685	.454	.385	.333	.450	.382	.333	.441	.379	.332
FLOOR REFLECTANCE = 0.30										
0	1.316	1.316	1.316	1.316	1.266	1.266	1.266	1.176	1.176	1.176
0.1	1.262	1.171	1.116	1.070	1.129	1.086	1.043	1.063	1.027	.994
0.2	1.192	1.035	.960	.890	1.007	.940	.880	.957	.897	.852
0.3	1.131	.913	.838	.764	.907	.822	.752	.863	.785	.737
0.4	1.053	.824	.733	.661	.816	.723	.651	.778	.696	.642
0.5	.996	.748	.646	.574	.731	.638	.571	.705	.623	.563
0.6	.930	.673	.572	.507	.662	.570	.506	.635	.559	.502
0.7	.874	.613	.517	.450	.602	.511	.448	.578	.502	.445
0.8	.827	.554	.469	.403	.546	.463	.401	.534	.457	.399
0.9	.784	.509	.428	366	.502	.424	.365	.492	.419	.365
1.0	.743	.471	.391	.335	.466	.389	.335	.452	.384	.333

INTERFLECTANCE TABLE NO. 2.

C.I.E. Classification: Direct

Pattern of Distribution Curve { Upper Hemisphere #5 Lower Hemisphere #2

C.I.E. Distribution: Upward — 10
Downward — 90

Mounting Details: $\frac{h_m}{h} = 1$ (Surface)

k_r	Ceiling Reflectance 0.80				0.70			0.50		
	Wall Reflectance				Wall Reflectance			Wall Reflectance		
	0.80	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
FLOOR REFLECTANCE = 0.10										
0	1.065	1.065	1.065	1.065	1.043	1.043	1.043	1.000	1.000	1.000
0.1	1.051	.986	.953	.922	.963	.934	.906	.923	.898	.874
0.2	1.002	.902	.850	.800	.882	.830	.788	.848	.803	.766
0.3	.964	.825	.754	.697	.807	.742	.688	.770	.716	.670
0.4	.911	.749	.671	.609	.734	.660	.604	.702	.638	.590
0.5	.866	.680	.597	.535	.663	.588	.529	.634	.569	.518
0.6	.820	.620	.531	.473	.602	.523	.466	.577	.510	.457
0.7	.776	.564	.480	.421	.552	.474	.418	.528	.461	.410
0.8	.737	.519	.437	.378	.506	.430	.376	.486	.421	.371
0.9	.701	.475	.399	.346	.466	.394	.342	.449	.386	.338
1.0	.668	.435	.365	.313	.429	.360	.311	.415	.354	.306
FLOOR REFLECTANCE = 0.30										
0	1.290	1.290	1.290	1.290	1.288	1.288	1.288	1.117	1.117	1.117
0.1	1.234	1.144	1.089	1.043	1.092	1.050	1.007	1.008	.973	.941
0.2	1.165	1.009	.933	.864	.972	.905	.846	.906	.848	.804
0.3	1.104	.888	.812	.738	.874	.789	.720	.817	.741	.694
0.4	1.028	.800	.708	.635	.784	.692	.621	.736	.656	.603
0.5	.972	.724	.622	.550	.702	.610	.543	.666	.586	.527
0.6	.908	.650	.549	.484	.634	.543	.479	.599	.525	.469
0.7	.853	.591	.495	.428	.576	.486	.423	.545	.471	.415
0.8	.806	.533	.448	.381	.522	.439	.378	.503	.427	.371
0.9	.764	.489	.407	.345	.479	.401	.342	.463	.391	.338
1.0	.724	.452	.371	.315	.444	.367	.313	.425	.358	.308

INTERFLECTANCE TABLE NO. 3.

C.I.E. Classification: Semi-Direct

Pattern of Distribution Curve { Upper Hemisphere #5 / Lower Hemisphere #2

C.I.E. Distribution: Upward — 20, Downward — 80

Mounting Details: $\frac{h_m}{h} = 1$ (Surface)

k_r	Ceiling Reflectance 0.80				0.70			0.50		
	Wall Reflectance				Wall Reflectance			Wall Reflectance		
	0.80	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
	FLOOR REFLECTANCE = 0.10									
0	1.044	1.044	1.044	1.044	1.011	1.011	1.011	.948	.948	.948
0.1	1.026	.962	.929	.898	.930	.902	.873	.872	.848	.825
0.2	.978	.877	.825	.776	.850	.799	.756	.800	.757	.720
0.3	.940	.800	.729	.673	.776	.711	.658	.726	.673	.628
0.4	.889	.726	.647	.584	.705	.630	.574	.661	.598	.551
0.5	.845	.657	.574	.511	.636	.560	.502	.597	.533	.483
0.6	.799	.599	.509	.450	.576	.497	.441	.542	.477	.425
0.7	.757	.543	.458	.399	.527	.450	.394	.496	.431	.380
0.8	.719	.498	.416	.357	.483	.407	.352	.456	.393	.349
0.9	.683	.456	.378	.325	.443	.372	.320	.421	.359	.312
1.0	.650	.416	.346	.293	.407	.339	.290	.388	.328	.281
	FLOOR REFLECTANCE = 0.30									
0	1.263	1.263	1.263	1.263	1.190	1.190	1.190	1.058	1.058	1.058
0.1	1.206	1.116	1.062	1.016	1.055	1.013	.971	.953	.919	.888
0.2	1.137	.982	.906	.838	.937	.870	.812	.856	.799	.756
0.3	1.077	.864	.786	.712	.840	.757	.689	.770	.697	.651
0.4	1.003	.775	.683	.608	.753	.662	.592	.693	.616	.564
0.5	.948	.700	.599	.526	.673	.581	.515	.626	.549	.492
0.6	.885	.628	.527	.460	.607	.516	.453	.563	.491	.436
0.7	.832	.569	.473	.406	.550	.461	.398	.512	.439	.385
0.8	.786	.513	.426	.360	.498	.415	.354	.472	.399	.343
0.9	.744	.469	.386	.324	.456	.378	.320	.434	.364	.312
1.0	.705	.432	.351	.294	.421	.345	.291	.398	.332	.284

INTERFLECTANCE TABLE NO. 4.

C.I.E. Classification: Semi-Direct

Pattern of Distribution Curve { Upper Hemisphere #5 / Lower Hemisphere #2

C.I.E. Distribution: Upward — 30, Downward — 70

Mounting Details: $\frac{h_m}{h} = 1$ (Surface)

k_r	Ceiling Reflectance 0.80				0.70			0.50		
	Wall Reflectance				Wall Reflectance			Wall Reflectance		
	0.80	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
	FLOOR REFLECTANCE = 0.10									
0	1.022	1.022	1.022	1.022	.978	.978	.978	.895	.895	.895
0.1	1.002	.938	.905	.875	.898	.870	.840	.822	.799	.776
0.2	.954	.853	.799	.752	.818	.768	.724	.752	.710	.674
0.3	.916	.776	.704	.648	.744	.681	.627	.681	.630	.587
0.4	.866	.702	.622	.560	.675	.601	.545	.621	.559	.513
0.5	.823	.634	.551	.488	.608	.533	.474	.559	.497	.448
0.6	.779	.577	.488	.428	.551	.471	.416	.508	.444	.393
0.7	.737	.523	.437	.378	.503	.425	.369	.464	.400	.351
0.8	.700	.478	.395	.336	.460	.383	.329	.427	.364	.315
0.9	.665	.436	.358	.304	.421	.349	.297	.393	.332	.285
1.0	.632	.397	.326	.273	.386	.317	.268	.362	.302	.256
	FLOOR REFLECTANCE = 0.30									
0	1.237	1.237	1.237	1.237	1.152	1.152	1.152	1.000	1.000	1.000
0.1	1.179	1.089	1.035	.989	1.018	.976	.935	.898	.865	.835
0.2	1.110	.956	.879	.812	.902	.835	.778	.805	.749	.707
0.3	1.050	.840	.759	.686	.807	.724	.658	.724	.653	.607
0.4	.979	.751	.658	.583	.721	.631	.562	.651	.576	.525
0.5	.924	.676	.575	.502	.643	.553	.487	.587	.512	.456
0.6	.863	.605	.504	.437	.580	.489	.426	.527	.456	.403
0.7	.811	.547	.450	.383	.525	.436	.374	.480	.408	.355
0.8	.765	.492	.404	.338	.474	.391	.330	.441	.369	.315
0.9	.724	.449	.365	.303	.433	.355	.298	.405	.336	.286
1.0	.685	.412	.330	.274	.399	.322	.270	.371	.306	.259

INTERFLECTANCE TABLE NO. 5.

C.I.E. Classification: Direct

Pattern of Distribution Curve { Upper Hemisphere — Lower Hemisphere #3

C.I.E. Distribution: Upward — 0
Downward — 100

Mounting Details: $\frac{h_m}{h} = \frac{3}{4}$ (Pendent)

k_r	Ceiling Reflectance 0.80				0.70			0.50		
	Wall Reflectance				Wall Reflectance			Wall Reflectance		
	0.80	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
FLOOR REFLECTANCE = 0.10										
0	1.087	1.087	1.087	1.087	1.075	1.075	1.075	1.053	1.053	1.053
0.1	1.080	1.042	1.015	.989	1.029	1.005	.981	1.007	.986	.967
0.2	1.072	.982	.938	.899	.973	.933	.895	.949	.915	.882
0.3	1.039	.924	.866	.818	.914	.859	.815	.892	.846	.807
0.4	1.005	.863	.793	.744	.853	.790	.742	.831	.780	.735
0.5	.962	.799	.727	.673	.790	.723	.672	.772	.714	.669
0.6	.919	.743	.667	.614	.733	.664	.612	.713	.657	.612
0.7	.879	.689	.616	.563	.682	.612	.562	.668	.606	.560
0.8	.839	.642	.567	.516	.630	.566	.515	.620	.563	.514
0.9	.803	.597	.527	.478	.587	.526	.478	.580	.522	.477
1.0	.768	.555	.491	.442	.550	.489	.442	.540	.484	.442
FLOOR REFLECTANCE = 0.30										
0	1.316	1.316	1.316	1.316	1.266	1.266	1.266	1.176	1.176	1.176
0.1	1.285	1.206	1.160	1.118	1.166	1.127	1.092	1.099	1.068	1.041
0.2	1.230	1.104	1.030	.966	1.064	1.016	.966	1.019	.964	.934
0.3	1.190	1.013	.930	.863	.989	.914	.852	.946	.885	.836
0.4	1.128	.929	.842	.772	.905	.826	.764	.874	.810	.755
0.5	1.074	.850	.760	.692	.834	.750	.690	.806	.735	.681
0.6	1.016	.782	.692	.625	.768	.686	.625	.744	.672	.618
0.7	.966	.720	.633	.571	.710	.628	.571	.690	.618	.565
0.8	.917	.666	.584	.525	.658	.576	.524	.641	.569	.519
0.9	.874	.619	.539	.482	.612	.532	.480	.595	.527	.479
1.0	.830	.578	.498	.445	.566	.495	.445	.554	.491	.444

INTERFLECTANCE TABLE NO. 6.

C.I.E. Classification: Direct

Pattern of Distribution Curve { Upper Hemisphere #5 Lower Hemisphere #3

C.I.E. Distribution: Upward — 10
Downward — 90

Mounting Details: $\frac{h_m}{h} = \frac{3}{4}$ (Pendent)

k_r	Ceiling Reflectance 0.80				0.70			0.50		
	Wall Reflectance				Wall Reflectance			Wall Reflectance		
	0.80	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
FLOOR REFLECTANCE = 0.10										
0	1.065	1.065	1.065	1.065	1.043	1.043	1.043	1.000	1.000	1.000
0.1	1.055	1.015	.987	.961	.993	.969	.944	.953	.932	.914
0.2	1.044	.952	.906	.867	.935	.894	.856	.896	.862	.829
0.3	1.010	.892	.832	.784	.875	.820	.775	.840	.794	.756
0.4	.975	.831	.759	.709	.814	.750	.702	.781	.730	.686
0.5	.933	.767	.695	.638	.752	.685	.633	.725	.667	.622
0.6	.890	.711	.634	.579	.697	.627	.574	.668	.613	.568
0.7	.851	.658	.583	.529	.647	.576	.526	.625	.564	.518
0.8	.812	.611	.535	.483	.596	.531	.480	.580	.523	.474
0.9	.777	.567	.496	.446	.555	.492	.444	.542	.484	.439
1.0	.742	.526	.461	.411	.519	.457	.409	.504	.448	.406
FLOOR REFLECTANCE = 0.30										
0	1.290	1.290	1.290	1.290	1.228	1.228	1.228	1.117	1.117	1.117
0.1	1.255	1.175	1.128	1.086	1.125	1.086	1.051	1.040	1.010	.983
0.2	1.199	1.071	.996	.932	1.023	.974	.924	.962	.908	.878
0.3	1.157	.979	.895	.827	.947	.872	.810	.891	.831	.783
0.4	1.096	.893	.806	.735	.864	.785	.723	.822	.758	.705
0.5	1.042	.816	.725	.656	.794	.710	.650	.756	.687	.634
0.6	.985	.748	.657	.590	.730	.647	.586	.697	.626	.573
0.7	.936	.687	.599	.537	.673	.591	.534	.646	.575	.523
0.8	.887	.634	.551	.491	.623	.541	.488	.599	.529	.479
0.9	.845	.588	.507	.449	.578	.498	.446	.556	.489	.441
1.0	.802	.548	.467	.414	.534	.462	.412	.517	.454	.408

INTERFLECTANCE TABLE NO. 7.

C.I.E. Classification: Semi-Direct

Pattern of Distribution Curve { Upper Hemisphere #5 / Lower Hemisphere #3

C.I.E. Distribution: Upward — 20
Downward — 80

Mounting Details: $\frac{h_m}{h} = \frac{3}{4}$ (Pendent)

k_r	Ceiling Reflectance 0.80				0.70			0.50		
	Wall Reflectance				Wall Reflectance			Wall Reflectance		
	0.80	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
FLOOR REFLECTANCE = 0.10										
0	1.044	1.044	1.044	1.044	1.011	1.011	1.011	.948	.948	.948
0.1	1.030	.988	.959	.933	.957	.932	.907	.899	.879	.860
0.2	1.015	.922	.875	.835	.896	.856	.816	.843	.809	.777
0.3	.981	.860	.798	.750	.836	.780	.735	.788	.743	.704
0.4	.946	.798	.724	.673	.776	.711	.662	.732	.681	.637
0.5	.904	.735	.661	.603	.715	.647	.594	.677	.620	.576
0.6	.862	.679	.601	.545	.660	.589	.537	.624	.568	.524
0.7	.823	.627	.550	.494	.611	.540	.489	.583	.522	.476
0.8	.785	.581	.503	.451	.563	.496	.445	.540	.483	.435
0.9	.750	.537	.465	.414	.522	.459	.410	.503	.446	.401
1.0	.716	.497	.431	.380	.487	.424	.377	.468	.412	.369
FLOOR REFLECTANCE = 0.30										
0	1.263	1.263	1.263	1.263	1.190	1.190	1.190	1.058	1.058	1.058
0.1	1.225	1.144	1.097	1.055	1.085	1.046	1.010	.982	.952	.926
0.2	1.168	1.038	.962	.899	.982	.931	.881	.905	.852	.821
0.3	1.124	.944	.859	.791	.906	.830	.769	.837	.777	.730
0.4	1.063	.859	.770	.698	.824	.744	.682	.770	.707	.654
0.5	1.010	.782	.690	.621	.755	.671	.610	.707	.639	.586
0.6	.954	.715	.623	.555	.692	.609	.548	.650	.581	.529
0.7	.905	.655	.565	.502	.637	.554	.497	.602	.532	.481
0.8	.858	.602	.518	.457	.587	.505	.452	.558	.488	.439
0.9	.816	.557	.475	.417	.544	.464	.412	.517	.450	.403
1.0	.774	.518	.436	.382	.501	.429	.379	.480	.418	.372

INTERFLECTANCE TABLE NO. 8.

C.I.E. Classification: Semi-Direct

Pattern of Distribution Curve { Upper Hemisphere #5 / Lower Hemisphere #3

C.I.E. Distribution: Upward — 30
Downward — 70

Mounting Details: $\frac{h_m}{h} = \frac{3}{4}$ (Pendent)

k_r	Ceiling Reflectance 0.80				0.70			0.50		
	Wall Reflectance				Wall Reflectance			Wall Reflectance		
	0.80	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
FLOOR REFLECTANCE = 0.10										
0	1.022	1.022	1.022	1.022	.978	.978	.978	.895	.895	.895
0.1	1.004	.960	.932	.905	.921	.896	.871	.846	.825	.806
0.2	.987	.892	.844	.803	.858	.817	.776	.790	.756	.724
0.3	.952	.839	.764	.715	.798	.741	.694	.736	.691	.653
0.4	.916	.766	.690	.638	.737	.672	.621	.682	.631	.588
0.5	.875	.702	.628	.569	.678	.608	.556	.630	.573	.530
0.6	.833	.648	.567	.510	.624	.552	.500	.579	.524	.479
0.7	.795	.595	.518	.462	.576	.504	.452	.540	.480	.435
0.8	.758	.550	.471	.418	.530	.462	.410	.499	.443	.395
0.9	.724	.507	.433	.382	.490	.425	.376	.465	.408	.363
1.0	.691	.468	.400	.349	.456	.392	.344	.431	.376	.332
FLOOR REFLECTANCE = 0.30										
0	1.237	1.237	1.237	1.237	1.152	1.152	1.152	1.000	1.000	1.000
0.1	1.195	1.114	1.066	1.023	1.044	1.005	.970	.923	.894	.868
0.2	1.137	1.004	.928	.865	.942	.888	.838	.849	.796	.765
0.3	1.092	.910	.824	.755	.864	.789	.728	.782	.723	.677
0.4	1.031	.824	.735	.661	.784	.703	.641	.718	.656	.604
0.5	.978	.747	.655	.585	.716	.632	.570	.658	.590	.539
0.6	.923	.681	.588	.520	.654	.570	.510	.604	.536	.484
0.7	.875	.622	.532	.468	.600	.518	.460	.558	.489	.439
0.8	.828	.571	.485	.423	.552	.470	.417	.516	.448	.399
0.9	.787	.526	.443	.384	.510	.430	.378	.477	.412	.365
1.0	.746	.487	.405	.351	.469	.397	.347	.443	.381	.337

INTERFLECTANCE TABLE NO. 9.

C.I.E. Classification: Semi-Direct

Pattern of Distribution Curve { **Upper Hemisphere #5** / **Lower Hemisphere #3**

C.I.E. Distribution: Upward — 40
Downward — 60

Mounting Details: $\frac{h_m}{h} = \frac{3}{4}$ **(Pendent)**

k_r	Ceiling Reflectance 0.80				0.70			0.50		
	Wall Reflectance				Wall Reflectance			Wall Reflectance		
	0.80	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
	FLOOR REFLECTANCE = 0.10									
0	1.000	1.000	1.000	1.000	.946	.946	.946	.842	.842	.842
0.1	.979	.933	.904	.877	.885	.860	.834	.792	.772	.753
0.2	.958	.862	.812	.771	.820	.779	.737	.737	.703	.672
0.3	.923	.797	.730	.681	.759	.701	.654	.684	.639	.602
0.4	.886	.734	.656	.602	.699	.632	.581	.633	.581	.539
0.5	.846	.670	.594	.534	.640	.570	.517	.583	.526	.483
0.6	.805	.616	.534	.476	.588	.514	.462	.535	.479	.435
0.7	.767	.564	.485	.429	.541	.468	.416	.497	.438	.393
0.8	.731	.519	.439	.385	.496	.427	.375	.459	.403	.356
0.9	.697	.477	.402	.350	.458	.392	.342	.427	.370	.325
1.0	.665	.439	.370	.318	.424	.360	.312	.395	.340	.296
	FLOOR REFLECTANCE = 0.30									
0	1.211	1.211	1.211	1.211	1.114	1.114	1.114	.941	.941	.941
0.1	1.165	1.083	1.034	.991	1.004	.965	.929	.865	.836	.811
0.2	1.106	.971	.894	.831	.901	.846	.796	.792	.740	.708
0.3	1.059	.875	.788	.719	.823	.747	.686	.727	.669	.624
0.4	.999	.789	.699	.624	.743	.662	.600	.666	.604	.553
0.5	.946	.713	.620	.549	.676	.592	.530	.608	.542	.491
0.6	.892	.648	.553	.485	.616	.532	.471	.557	.490	.440
0.7	.845	.590	.498	.434	.564	.481	.423	.514	.446	.397
0.8	.799	.539	.452	.389	.517	.435	.381	.475	.407	.359
0.9	.758	.495	.411	.351	.476	.396	.344	.438	.373	.327
1.0	.718	.457	.374	.320	.436	.364	.314	.406	.345	.301

INTERFLECTANCE TABLE NO. 10.

C.I.E. Classification, Direct-Indirect

Pattern of Distribution Curve { **Upper Hemisphere #5** / **Lower Hemisphere #3**

C.I.E. Distribution: Upward — 50
Downward — 50

Mounting Details: $\frac{h_m}{h} = \frac{3}{4}$ **(Pendent)**

k_r	Ceiling Reflectance 0.80				0.70			0.50		
	Wall Reflectance				Wall Reflectance			Wall Reflectance		
	0.80	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
	FLOOR REFLECTANCE = 0.10									
0	.978	.978	.978	.978	.914	.914	.914	.790	.790	.790
0.1	.954	.906	.876	.848	.848	.824	.797	.738	.718	.700
0.2	.930	.832	.780	.740	.782	.740	.697	.684	.650	.619
0.3	.894	.765	.696	.647	.720	.662	.614	.632	.588	.550
0.4	.856	.702	.622	.567	.660	.592	.541	.583	.532	.490
0.5	.817	.638	.560	.499	.602	.532	.478	.536	.480	.436
0.6	.776	.584	.501	.441	.552	.477	.424	.490	.435	.391
0.7	.740	.533	.452	.394	.506	.432	.380	.454	.396	.351
0.8	.704	.488	.408	.352	.462	.392	.340	.419	.363	.316
0.9	.671	.448	.371	.318	.426	.358	.308	.388	.333	.288
1.0	.639	.410	.340	.287	.393	.328	.279	.359	.304	.260
	FLOOR REFLECTANCE = 0.30									
0	1.184	1.184	1.184	1.184	1.076	1.076	1.076	.882	.882	.882
0.1	1.134	1.052	1.002	.959	.963	.924	.888	.806	.778	.753
0.2	1.074	.938	.860	.798	.860	.804	.754	.735	.684	.652
0.3	1.026	.840	.753	.683	.781	.705	.644	.672	.615	.570
0.4	.966	.755	.663	.586	.702	.622	.560	.614	.552	.503
0.5	.914	.679	.584	.514	.636	.552	.490	.558	.494	.444
0.6	.862	.614	.518	.450	.578	.493	.432	.510	.444	.396
0.7	.814	.557	.464	.400	.527	.444	.386	.470	.404	.355
0.8	.769	.507	.419	.356	.482	.400	.345	.433	.367	.320
0.9	.729	.464	.379	.318	.442	.362	.310	.399	.335	.290
1.0	.690	.427	.344	.288	.404	.331	.281	.368	.308	.265

INTERFLECTANCE TABLE NO. 11.

C.I.E. Classification, Direct-Indirect

Pattern of Distribution Curve { **Upper Hemisphere #5** / **Lower Hemisphere #3**

C.I.E. Distribution: **Upward — 60** / **Downward — 40**

Mounting Details: $\frac{h_m}{h} = \frac{3}{4}$ **(Pendent)**

k_r	Ceiling Reflectance 0.80				0.70			0.50		
	Wall Reflectance				Wall Reflectance			Wall Reflectance		
	0.80	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
FLOOR REFLECTANCE = 0.10										
0	.957	.957	.957	.957	.882	.882	.882	.737	.737	.737
0.1	.929	.879	.848	.820	.812	.787	.760	.684	.664	.646
0.2	.902	.803	.749	.708	.743	.701	.658	.632	.596	.566
0.3	.864	.733	.661	.613	.681	.623	.574	.580	.536	.499
0.4	.827	.669	.587	.532	.621	.553	.501	.533	.482	.441
0.5	.788	.606	.526	.464	.565	.494	.439	.488	.433	.390
0.6	.747	.552	.468	.406	.515	.440	.387	.445	.391	.347
0.7	.712	.502	.419	.360	.470	.397	.343	.412	.353	.309
0.8	.678	.458	.376	.320	.429	.357	.306	.379	.323	.276
0.9	.645	.418	.340	.285	.393	.324	.275	.350	.295	.250
1.0	.613	.380	.310	.256	.362	.295	.246	.323	.268	.223
FLOOR REFLECTANCE = 0.30										
0	1.158	1.158	1.158	1.158	1.038	1.038	1.038	.823	.823	.823
0.1	1.104	1.021	.971	.927	.922	.883	.847	.747	.720	.695
0.2	1.043	.905	.826	.764	.819	.761	.711	.678	.629	.596
0.3	.993	.806	.718	.647	.739	.663	.603	.618	.561	.517
0.4	.934	.726	.627	.549	.662	.581	.519	.563	.501	.453
0.5	.883	.645	.549	.478	.597	.513	.451	.509	.446	.397
0.6	.831	.580	.484	.414	.539	.454	.394	.463	.399	.351
0.7	.784	.524	.430	.365	.490	.407	.348	.426	.361	.312
0.8	.739	.475	.386	.322	.446	.364	.309	.391	.327	.280
0.9	.700	.434	.347	.286	.408	.320	.276	.360	.297	.252
1.0	.663	.397	.313	.257	.372	.298	.248	.331	.271	.226

INTERFLECTANCE TABLE NO. 12.

C.I.E. Classification: Semi-Indirect

Pattern of Distribution Curve { **Upper Hemisphere #5** / **Lower Hemisphere #3**

C.I.E. Distribution: **Upward — 70** / **Downward — 30**

Mounting Details: $\frac{h_m}{h} = \frac{3}{4}$ **(Pendent)**

k_r	Ceiling Reflectance 0.80				0.70			0.50		
	Wall Reflectance				Wall Reflectance			Wall Reflectance		
	0.80	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
FLOOR REFLECTANCE = 0.10										
0	.935	.935	.935	.935	.850	.850	.850	.684	.684	.684
0.1	.904	.852	.820	.792	.776	.751	.723	.630	.611	.592
0.2	.873	.773	.718	.676	.705	.663	.618	.579	.543	.514
0.3	.835	.701	.627	.579	.642	.583	.534	.528	.484	.448
0.4	.797	.637	.553	.496	.583	.514	.461	.484	.432	.392
0.5	.759	.574	.492	.429	.527	.456	.400	.441	.386	.344
0.6	.719	.520	.435	.372	.479	.402	.350	.401	.346	.303
0.7	.684	.471	.386	.326	.435	.361	.306	.369	.311	.267
0.8	.651	.427	.344	.287	.396	.322	.271	.339	.283	.237
0.9	.618	.388	.309	.253	.361	.291	.241	.312	.257	.212
1.0	.587	.351	.280	.225	.330	.263	.214	.287	.232	.187
FLOOR REFLECTANCE = 0.30										
0	1.132	1.132	1.132	1.132	1.000	1.000	1.000	.764	.764	.764
0.1	1.074	.990	.940	.895	.882	.843	.806	.689	.662	.638
0.2	1.012	.872	.792	.730	.778	.718	.668	.621	.573	.539
0.3	.960	.771	.682	.611	.698	.621	.562	.563	.507	.464
0.4	.902	.685	.591	.512	.622	.540	.478	.511	.450	.402
0.5	.851	.611	.514	.442	.558	.474	.411	.460	.398	.349
0.6	.800	.547	.449	.379	.501	.416	.356	.416	.354	.306
0.7	.754	.492	.396	.331	.454	.370	.311	.382	.318	.270
0.8	.710	.443	.353	.288	.411	.329	.273	.350	.286	.240
0.9	.671	.403	.315	.253	.374	.295	.242	.321	.258	.214
1.0	.635	.367	.282	.226	.339	.265	.215	.294	.235	.193

INTERFLECTANCE TABLE NO. 13.

C.I.E. Classification: Semi-Indirect

Pattern of Distribution Curve { Upper Hemisphere #5 / Lower Hemisphere #3

C.I.E. Distribution: Upward — 80
Downward — 20

Mounting Details: $\frac{h_m}{h} = \frac{3}{4}$ (Pendent)

k_r	Ceiling Reflectance 0.80				0.70			0.50		
	Wall Reflectance				Wall Reflectance			Wall Reflectance		
	0.80	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
FLOOR REFLECTANCE = 0.10										
0	.913	.913	.913	.913	.817	.817	.817	.631	.631	.631
0.1	.878	.824	.793	.764	.740	.715	.687	.577	.551	.539
0.2	.845	.743	.686	.644	.667	.624	.579	.526	.490	.461
0.3	.806	.670	.593	.544	.604	.544	.493	.476	.432	.397
0.4	.767	.605	.519	.461	.544	.474	.420	.434	.382	.343
0.5	.730	.541	.459	.395	.490	.417	.362	.394	.339	.297
0.6	.690	.489	.401	.337	.443	.365	.312	.356	.302	.258
0.7	.656	.439	.354	.293	.400	.325	.270	.326	.269	.226
0.8	.624	.396	.312	.254	.362	.288	.236	.298	.243	.197
0.9	.592	.358	.277	.221	.329	.257	.207	.274	.219	.174
1.0	.562	.322	.249	.194	.299	.231	.181	.250	.196	.150
FLOOR REFLECTANCE = 0.30										
0	1.106	1.106	1.106	1.106	.962	.962	.962	.706	.706	.706
0.1	1.044	.960	.908	.864	.841	.802	.766	.630	.604	.580
0.2	.981	.838	.758	.696	.738	.676	.626	.565	.517	.483
0.3	.928	.737	.647	.575	.656	.580	.520	.508	.453	.411
0.4	.870	.650	.556	.475	.581	.499	.437	.459	.398	.352
0.5	.819	.576	.479	.406	.518	.434	.371	.410	.349	.302
0.6	.769	.513	.414	.344	.463	.377	.317	.370	.308	.262
0.7	.724	.459	.363	.297	.417	.334	.274	.338	.275	.228
0.8	.680	.412	.320	.254	.376	.294	.238	.308	.246	.200
0.9	.642	.372	.283	.220	.340	.261	.208	.281	.220	.176
1.0	.607	.336	.251	.195	.307	.233	.183	.257	.198	.158

INTERFLECTANCE TABLE NO. 14.

C.I.E. Classification: Semi-Indirect

Pattern of Distribution Curve { Upper Hemisphere #5 / Lower Hemisphere #3

C.I.E. Distribution: Upward — 90
Downward — 10

Mounting Details: $\frac{h_m}{h} = \frac{3}{4}$ (Pendent)

k_r	Ceiling Reflectance 0.80				0.70			0.50		
	Wall Reflectance				Wall Reflectance			Wall Reflectance		
	0.80	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
FLOOR REFLECTANCE = 0.10										
0	.892	.892	.892	.892	.785	.785	.785	.579	.579	.579
0.1	.853	.797	.765	.736	.704	.678	.650	.523	.504	.486
0.2	.816	.713	.654	.612	.628	.586	.540	.473	.437	.409
0.3	.777	.638	.559	.510	.565	.504	.453	.424	.381	.345
0.4	.738	.573	.484	.425	.506	.434	.380	.385	.333	.294
0.5	.701	.509	.425	.360	.453	.379	.323	.346	.292	.250
0.6	.662	.457	.368	.303	.406	.327	.274	.312	.257	.214
0.7	.628	.408	.321	.259	.364	.289	.234	.284	.227	.184
0.8	.597	.366	.280	.222	.328	.253	.201	.258	.203	.158
0.9	.565	.328	.246	.189	.296	.224	.173	.235	.181	.136
1.0	.536	.293	.219	.163	.267	.198	.149	.214	.160	.114
FLOOR REFLECTANCE = 0.30										
0	1.079	1.079	1.079	1.079	.924	.924	.924	.647	.647	.647
0.1	1.014	.929	.876	.832	.801	.762	.725	.572	.546	.523
0.2	.950	.805	.724	.663	.697	.633	.584	.508	.461	.426
0.3	.895	.702	.611	.539	.615	.538	.478	.454	.399	.358
0.4	.837	.616	.520	.438	.540	.458	.396	.407	.346	.301
0.5	.787	.542	.441	.371	.478	.394	.331	.360	.301	.254
0.6	.738	.480	.380	.309	.425	.339	.278	.323	.262	.218
0.7	.693	.427	.329	.262	.380	.297	.237	.294	.232	.186
0.8	.651	.380	.287	.220	.340	.258	.202	.267	.205	.160
0.9	.613	.341	.251	.188	.306	.226	.174	.242	.181	.138
1.0	.579	.306	.220	.163	.274	.200	.150	.220	.162	.122

INTERFLECTANCE TABLE NO. 15.

C.I.E. Classification: Indirect

Pattern of Distribution Curve { Upper Hemisphere #5 / Lower Hemisphere —

C.I.E. Distribution: Upward — 100 / Downward — 0

Mounting Details: $\frac{h_m}{h} = \frac{3}{4}$ (Pendent)

k_r	Ceiling Reflectance 0.80				0.70			0.50		
	Wall Reflectance				Wall Reflectance			Wall Reflectance		
	0.80	0.50	0.30	0.10	0.50	0.30	0.10	0.50	0.30	0.10
FLOOR REFLECTANCE = 0.10										
0	.870	.870	.870	.870	.753	.753	.753	.526	.526	.526
0.1	.828	.770	.737	.708	.668	.642	.613	.469	.450	.432
0.2	.788	.683	.623	.580	.590	.547	.500	.420	.384	.356
0.3	.748	.606	.525	.476	.526	.465	.413	.372	.329	.294
0.4	.708	.540	.450	.390	.467	.395	.340	.335	.283	.245
0.5	.672	.477	.391	.325	.415	.341	.284	.299	.245	.204
0.6	.633	.425	.335	.268	.370	.290	.237	.267	.213	.170
0.7	.600	.377	.288	.225	.329	.253	.197	.241	.185	.142
0.8	.570	.335	.248	.189	.295	.218	.166	.218	.163	.118
0.9	.539	.298	.215	.157	.264	.190	.139	.197	.143	.098
1.0	.510	.264	.189	.132	.236	.166	.116	.178	.124	.077
FLOOR REFLECTANCE = 0.30										
0	1.053	1.053	1.053	1.053	.886	.886	.886	.588	.588	.588
0.1	.984	.898	.845	.800	.760	.721	.684	.513	.488	.465
0.2	.919	.772	.690	.629	.656	.591	.541	.451	.405	.370
0.3	.862	.668	.576	.503	.573	.496	.437	.399	.345	.305
0.4	.805	.581	.484	.401	.500	.417	.355	.355	.295	.251
0.5	.755	.508	.409	.335	.439	.355	.291	.311	.253	.207
0.6	.707	.446	.345	.274	.387	.300	.240	.276	.217	.173
0.7	.663	.394	.295	.228	.344	.260	.200	.250	.189	.144
0.8	.621	.348	.254	.186	.305	.223	.166	.225	.165	.120
0.9	.584	.310	.219	.155	.272	.193	.140	.203	.143	.100
1.0	.551	.276	.189	.132	.242	.167	.117	.183	.125	.086

(*Continued from page* 601)

4. The method by which manufacturers can obtain coefficients of utilization from these tables has been given. The keynote of this method is simplicity.
5. Interflectance values as tabulated herein have been compared with those obtained by earlier procedures. Agreement has been found to be within limits required by engineering practice.
6. The possibility of eventually extending this procedure to cover all types of luminaires has been reviewed.

References

1. Moon, Parry, and Spencer, D. E.: "Lighting Design by the Interflection Method," *J. Franklin Institute*, 242, 1946, p. 465-501.
2. Allphin, W.: "Numerical Room Ratios," ILLUMINATING ENGINEERING, Vol. XLVIII, p. 206 (April 1953).
3. Coradeschi, R. A., and Innis, L. E.: "An Application of the Interflection Theory to Commercial Practice," ILLUMINATING ENGINEERING, Vol. XLIII, p. 949 (November 1948).
4. Moon, Parry, and Spencer, D. E.: "Interflectance Calculations for Various Luminaires," *J. Franklin Institute*, 252, 1951, p. 11-31.
5. Jones, J. R., and Neidhart, J. J.: "The Zonal Method of Computing Coefficients of Utilization and Illumination on Room Surfaces," ILLUMINATING ENGINEERING, Vol. XLVIII, No. 3, p. 141 (March 1953).
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8. Burnham, R. D.: "An Appraisal of Illumination Calculations for Luminous Indirect Luminaires," ILLUMINATING ENGINEERING, Vol. XLVIII, p. 197 (April 1953).
9. *I.E.S. Lighting Handbook*, Second Edition, Illuminating Engineering Society, 1952, p. 9-15.

DISCUSSION

DOMINA EBERLE SPENCER*: Mr. Innis is to be congratulated on having applied the interflection method to the development of a ready tool for the fixture manufacturer. Merely by multiplying the tables at the end of his paper by the correct logance (efficiency), coefficients of utilization can be obtained for a wide variety of commercial luminaires.

An approximation that Professor Moon and I have made in some of our applications of the interflection method is clearly pointed out by Mr. Innis. We have sometimes neglected to include, in the light coming directly to the principal surface, that part of the direct light from the luminaires which goes to the portion of the walls below the principal surface. This is, however, a justifiable approximation in many cases.

The use of Equation (3) in place of Equation (5) introduces *no error* for

(a) Any type of lighting in a very large room,

(b) Perfectly diffusing luminous ceilings or equivalent luminous indirect lighting,

(c) The type of direct lighting considered in Q. and Q. Report No. 4[1] where the luminaires were designed to direct all the light to the floor.

It is an *adequate approximation* for any luminaire that sends most of its light upward to walls and ceilings. The only case in which there may be significant difference between the results obtained from the two equations occurs when a luminaire having a large downward component is used in a small room. In the only paper in which we have considered the calculation of light from such luminaires,

*University of Connecticut, Storrs, Conn.

Professor Moon and I have employed Equation (5). It should, however, be realized that discussions of such discrepancies should not be taken too seriously. In a small room, different geometric configurations of the luminaires give far greater discrepancies than those arising from the use of Equation (3) in place of Equation (5). It is impossible for *any lumen method* to describe, by a single number, the wide variety of lighting layouts that may be made by the illuminating engineer for a small room. He should recognize this fact and not waste too much time lamenting it.

The procedure employed by Innis differs slightly from the method[2] previously employed. While Professor Moon and I used pharos corresponding to a continuous distribution of the characteristic candlepower curve over the entire ceiling, Innis has chosen to modify the pharos ratios so that they correspond to a typical discreet spacing.

The discrepancies shown in Figs. 3, 6, and 7 are in all cases less than 10 per cent. Since further refinement in measurements is neither needed nor practicable in this field, the accuracy of both the earlier Coradeschi-Innis method[3] and the present Innis paper are satisfactory. It should not be forgotten that the method of employing canonical distributions also has its inherent approximations. It is using candlepower distributions, which should never be used with finite luminaires. The earlier method[3] employed by Coradeschi and Innis and now developed by Losh[4] is basically the best method. The fact that sufficiently accurate results can be obtained by employing a few canonical distributions is a fortunate coincidence not grounded on a firm foundation. Perhaps we are saved by the fact that a wide range of luminaires have essentially the same interflectance table. The interflection method is peculiarly insensitive to a number of possible changes.

I hope that Mr. Innis' paper will lead the way to a wider use of the interflection method by commercial fixture manufacturers.

L. E. INNIS*: I would like to thank Dr. Spencer for her comments and for the assistance she has given in the preparation of this paper. Her suggestions and criticisms are always more than welcome.

One point, I believe, needs a little more discussion and that is the use of the candlepower distribution curve. In this approach the flux ratios are obtained by dealing with a continuous luminous element each point of which has the same distribution as the finite fixture. Since we are dealing with points and since the inverse square law is rigorously correct for point sources, it would seem that the use of candlepower distribution curves, in this particular case, would introduce negligible error.

In comparing the direct flux ratios as given by this method with experimental results, they were found to be somewhat low even in rooms having a domance of $k_r = 0.2$. Since the effect of luminaire spacing is practically negligible in rooms of this size it was felt that the difference might possibly be due to other factors. For this reason corrections were made to bring the calculated results into agreement with experimental values. By this method the direct flux ratios are independent of distribution curve calculations.

While the laboratory method of actually measuring the flux ratios undoubtedly rests on a more solid foundation it seems to give substantially the same results as the more simplified procedure described in this paper for the types of distribution curves involved. It is, however, more laborious and time consuming and would require a photometric re-do for most of the luminaires in existence today. The laboratory method, however, does offer the advantage that it can be applied to any distribution pattern whereas the simplified procedure is limited to those types of distribution patterns discussed in the paper.

*Author.

1. Report No. 4 of the Committee on Standards of Quality and Quantity of Interior Illumination. ILLUMINATING ENGINEERING, Vol. XLII, p. 180 (1942).
2. Moon, Parry, and Spencer, D. E.: "Interflectance Calculations for Various Luminaires," *J. Franklin Institute*, 252, p. 11 (1951).
3. Coradeschi, R. A., and Innis, L. E.: "An Application of the Interflection Theory to Commercial Practice," ILLUMINATING ENGINEERING, Vol. XLIII, p. 949 (November 1949).
4. Losh, John A.: "A Rectangular Coordinate Photometer for Large-Area Luminaires," I.E.S. 1953 National Technical Conference Paper No. 24 (to be published).

Residence Lighting Practice Available Soon

The new I.E.S. Recommended Practice for Residence Lighting, which appeared in the August issue of I.E., is now complete with appendices and subject index and will soon be published in 44-page booklet form. The new practice is based upon earlier I.E.S. recommended practices, as well as upon the 1950 "Contemporary Lighting in Modern and Traditional Interiors" and the 1951 report "The Functional Visual Activities in the Home and the Location and Extent of the Associated Areas to be Illuminated." However, the new Recommended Practice represents an enlarged treatment of the subject and is specifically directed not only to Society members but also to residence architects, interior decorators and designers, lighting equipment designers, and educators.

Color Chart. — One feature of the new Recommended Practice for Residence Lighting is the color-chip chart which shows a suggested range of colors and their reflectances, for ceilings, walls and floors. For use with this chart, a full page of the report deals with the lighting environment to be created with colors and the effects of light upon them. Table II of the Practice furnishes details as to appearance of each of the colors under two different types of illuminants, their Munsell designations and reflectances.

The I.E.S. Recommended Practice for Residence Lighting is primarily devoted to the basic lighting requirements for family activities involving close vision, such as selection and placement of portable lamps for sewing, reading, reading in bed, desk work, piano playing, kitchen and laundry activities. It is completely illustrated and much of the regularly-used information is in table form.

Individual copies are $1.00 and may be purchased from Publications Office, I.E.S., 1860 Broadway, New York 23, N. Y. Quantity prices upon request, if quantities are required for distribution to customers and prospects.

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

The 1953 National Technical Conference

New York City, site of this year's Conference, was host to the biggest of them all, as of 1953 anyway. A total of 1009 were there — 750 delegates and 259 ladies. For statistical experts who like to compare, a boxed tabulation is shown, giving attendance figures for conferences and conventions in the past 30 years.

For skeptics who attribute the record-breaking attendance to cultural and other attractions of the city, we would refer to another record in New York — completely packed technical sessions for every paper.

There was considerable speculation before the conference, on the effect of separate banquet tickets, and a low registration fee of $5.00. Banquet attendance on the voluntary separate purchase system was 770, or over 70 per cent of all those registered. Quite thorough vindication of the new procedure.

National Officers Report

One of the highlights of every National I.E.S. Conference is the opening session, at which the national officers report on the Society's accomplishments for the year. Progress as an organization is reported by the out going President and the General Secretary; aims for the coming administration by the incoming President. This session is designed to review for the members their Society's affairs on a national scale. A complete record of the year's work, with financial statements and all statistics, will be given in the publication of the General Secretary's Report, scheduled for the December issue of I.E. President Strong's address "The 1953 Administration" appears on page 447 of the September issue. Incoming President Manwaring's address is published on page 450 of September I.E.

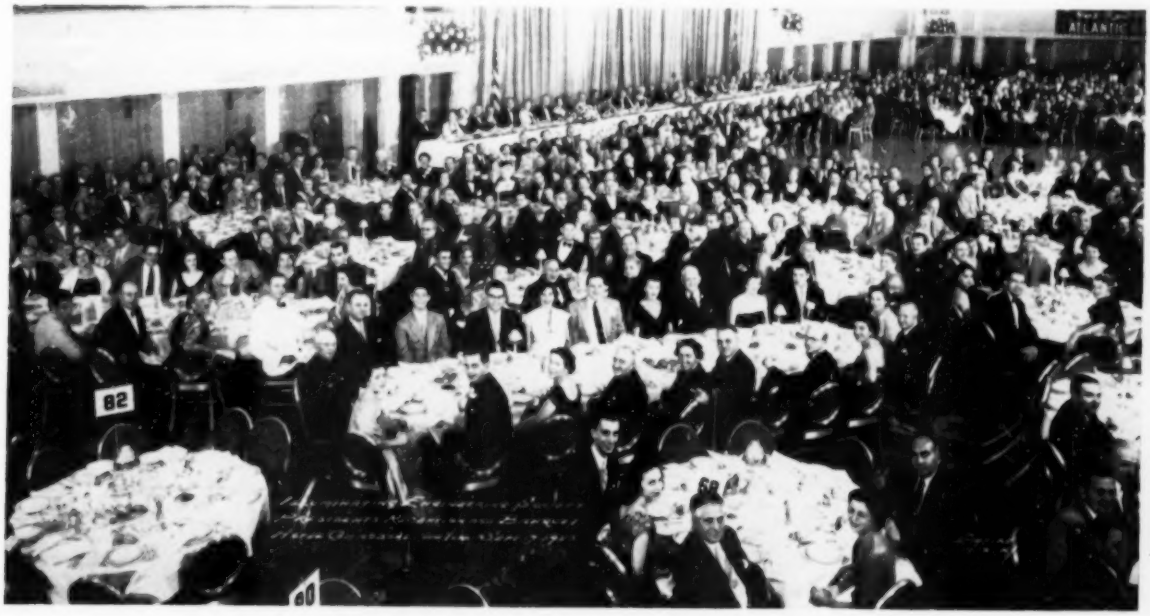
Conference Statistics

Time: September 14-17, 1953
Place: Hotel Commodore, New York, N. Y.
Attendance:

Registered Members	750
Ladies	259
	1009

Banquet Attendance: 770

Presiding at this session on Monday, September 14, was Hoyt P. Steele, Chairman of the National Technical Conference Committee. An additional feature of it was the opening address by Walter Sammis, President of the Edison Electric Institute, who spoke on "Light's Diamond Jubilee" being celebrated this year.



Some of the 770 members and guests at the banquet.

George H. Stickney, Charter Member, attending the opening session.

Prof. John Kraehenbuehl, H. H. Magdsick and President E. M. Strong.

Dr. and Mrs. H. C. Weston, distinguished guests from England.

Seen at the Conference

H. P. Steele, Chairman of the National Technical Conference Committee; C. C. Keller, Chairman of the Conference Executive Committee; and guest speaker at the opening session Walter Sammis.

Past President Walter Sturrock, Director W. A. Stannard, Vice-President R. F. Hartenstein and Past President S. G. Hibben.

At the session on Evaluation: standing, Dean Farnsworth, Carl Egeler, Willard Allphin and H. L. Logan; seated, W. P. Lowell and Dr. Domina Eberle Spencer.

T. C. Sargent, Chairman of the Progress Committee, with some of his props for the presentation of the Progress Report.

New Fellows Receive Pins

Thirteen of the 16 men elected as Fellows of the Society during the past year were present at the opening session, to receive the badge of their honor—the white Fellow lapel pin. President Strong made the presentation during an interesting ceremony at the end of the session. On hand to receive pins were:

J. W. Bateman, Toronto Section
G. R. Baumgartner, Cleveland Section
G. W. Beals, Connecticut Section
Dean Farnsworth, Connecticut Section
Glenn A. Fry, Ohio Valley Section
S. K. Guth, Cleveland Section
E. H. Hallman, Philadelphia Section
W. J. Kahler, Cleveland Section
W. P. Lowell, Jr., New England Section
W. M. Potter, Cleveland Section
E. H. Salter, New York Section
G. E. Shoemaker, Philadelphia Section
G. J. Taylor, New York Section

Additional pins were sent to absent Fellows:

R. M. Evans, Rochester Section
H. J. Cory Pearson, Indiana Section
Carl W. Zersen, Chicago Section.

Fellows elected during this past year, receiving the white Fellow-Grade pin are, seated: J. W. Bateman, W. R. Kahler, G. W. Beals, G. J. Taylor, S. K. Guth, G. E. Shoemaker; standing: Dean Farnsworth, E. H. Salter, W. M. Potter, G. A. Fry, W. P. Lowell, Jr., G. R. Baumgartner and E. B. Hallman. Not present to receive their pins were R. M. Evans, H. J. C. Pearson, and C. W. Zerson.

Light and Vision Session

A complete record of the technical program is included at the end of this report, for the record. Such listing, however, scarcely does justice to the especially valuable session Monday afternoon, a symposium on Light and Vision. The session featured two papers by distinguished British scientists, with supplementary discussion by leading American physicists. Mr. H. C. Weston, a Fellow of the British I.E.S., and Director of Research in Occupational Optics at the University of London, presented an address on "Visual Fatigue with Special Reference to Lighting." Mr. Weston's studies in this field, and his interesting slides, revealed effects of glare, among other factors, of particular interest to his American audience. His address will be published in full in a forthcoming issue of Illuminating Engineering.

The paper "Visual Factors in Lighting" by Dr. W. S. Stiles, was given in his absence by C. L. Crouch, I.E.S. Technical Director. Dr. Stiles, who is associated with the Department of Scientific and Industrial Research, National Physical Laboratory, Teddington, England, was unfortunately taken ill just prior to his scheduled trip to America. This paper also, together with the discussion of Dr. S. K. Guth, Dr. H. Richard Blackwell, Dr. Glenn A. Fry and Dr. Ward Harrison, will be published in the same issue of I.E., as a symposium on light and vision studies.

Progress Report

The popularity of this event grows with every Conference, and with good reason. Painstaking hard work assembles for the audience, all major developments in the lighting field, with actual equipment to demonstrate it. The Progress Report was again this year under the direction of T. C. (Ted) Sargent, Sylvania Electric Products Inc., Salem, with members of his committee assisting in the demonstrations. The scramble for seats at this event starts early, and latecomers are willing to stand for the entire session. Text of the Report is scheduled for publication in I.E., possibly January.

Were You There?

Conference Attendance Records for Past 30 Years

1923	Lake George, N. Y.	269	1938	Minneapolis, Minn.	641
1924	Briarcliff, N. Y.	362	1939	San Francisco, Calif.	411
1925	Detroit, Mich.	376	1940	Spring Lake, N. J.	611
1926	Spring Lake, N. J.	337	1941	Atlanta, Ga.	573
1927	Chicago, Ill.	489	1942	St. Louis, Mo.	516
1928	Toronto, Ont.	552	1943	New York, N. Y. (one day)	126
1929	Philadelphia, Pa.	745	1944	Chicago, Ill.	721
1930	Richmond, Va.	476	1945	No Conference	—
1931	Pittsburgh, Pa.	514	1946	Quebec, Que.	807
1932	Swampscott, Mass.	258	1947	New Orleans, La.	605
1933	Lake Delavan, Wisc.	440	1948	Boston, Mass.	906
1934	Baltimore, Md.	370	1949	French Lick, Ind.	668
1935	Cincinnati, Ohio	514	1950	Pasadena, Calif.	556
1936	Buffalo, N. Y.	639	1951	Washington, D. C.	765
1937	White Sulphur Springs, West Va.	462	1952	Chicago, Ill.	859

1953 **New York, N. Y.** 1009

Lighting Job Contest

The outstanding success of the national contest for "My Most Interesting Lighting Job" will undoubtedly establish it as an annual affair of major importance. This second contest featured nine entries at the national level, which represented "finalists" in local and regional contests in which a total of 118 members had participated. The program is under the direction of the Lighting Service Forum, Lee E. Tayler, Chairman.

Grand Finalist winners of the contest were:

First prize, $100.00: Merrill R. Humber, winner for Northern California Section and South Pacific Coast Region. Lighting Broadway Tunnel.

Second prize, $50.00: Nick Stuffer, winner for Cleveland Section and Great Lakes Region. Integrated Functional Ceiling of an Executive Office.

Third prize, $25.00: Mario G. Zervigon, winner for New Orleans Section and Southern Region. Floodlighting a Modern Building.

Fourth prize, $15.00: A tie for this place went to:

L. E. Spears, winner for Pittsburgh Section and East Central Region. Lighting a Jewelry Store.

Henry J. Koether, winner for Milwaukee Section and Midwestern Region. Lighting "The Grand."

Runners up in the contest were:

Benoit C. Doucet, Curtis Lighting, Inc., Montreal. "Re-Lighting St. Ensebe Church." This job previously took first place for the Montreal Section and the Canadian Region.

My Most Interesting Lighting Job Contest Awards: Henry Koether gets his certificate and check from President Strong. Awaiting their turn are Nick Stuffer and Merrill Humber, also winners in the contest.

E. J. Whitlow, McClure Electric Co., Dallas, Texas. "Lighting a Television Broadcasting Tower." The entry was first place winner in Southwestern Region's contest. (Mr. Whitlow's entry was presented in his absence by M. J. Myers.)

Don E. Frank, Columbia Electric & Manufacturing Co., Spokane, Wash. "Re-Lighting a Bank Lobby." Mr. Frank's entry, presented in his absence by Walter Toly, represented the Pacific Northwest Region.

R. R. Duncan, Jr., New Bedford Gas and Edison Light Co., New Bedford, Mass. "Harvard Trust Company Director's Room." This job was winner for the New England Section and Northeastern Region.

Judges at the National contest were acknowledged leaders in illumination. These were: Prof. E. M. Strong, Cornell University, Ithaca, N. Y.; C. L. Crouch, Technical Director of I.E.S.; S. G. Hibben, Westinghouse Electric Corp., Bloomfield, N. J.; W. F. Little, Electrical Testing Laboratories Inc.; Lester H. Graves, (retired), Past President of I.E.S.

Residence Lighting Forum Session

Another special session at the Conference which rates considerable space in the record was the Residence Lighting Forum Session held Thursday morning. The meeting was under the Chairmanship of Edith L. Buchholtz, home lighting consultant with Westinghouse Lamp Division.

Latest developments and techniques in home lighting were discussed by five authorities in the residence lighting field. Installations described ranged from a typical small development house to a luxurious city apartment, and included all rooms of the home, and even a lovely spring garden lighted for night time enjoyment. Special attention was given to the problems created by some of the current trends in residence architecture, such as the increasing use of large window areas, open planning, sloping ceilings, and exposed beams. One of the chief emphases of the meeting, stressed by all the speakers, was the necessity for *early* planning.

Virginia Skinner, home lighting director of the Long Island Lighting Co., speaking on "Practical Lighting Features in Long Island Homes," described two houses of quite different price-levels.

An all-electric home in a suburb of Nashville, Tenn., was described in detail by May Love Gale, home economist of the Tennessee Valley Authority, who called her talk "Electrical Planning Includes Good Lighting."

Third speaker on the program was Kerr Sanders of the Chicago Lighting Institute, who described "New Lighting Installations In and Around Chicago." Mr. Sanders showed photographs of a number of interesting and unusual homes, Some of them in the luxury class and several of them very modern in style.

An interesting analysis of "Solutions to Lighting Problems Created by the New Architecture" was presented by Mary Taepke, assistant to the director of home service of the Detroit Edison Co. Miss Taepke described methods of lighting treatment that have been successful in a number of modern homes in the Detroit area.

Emily Alexander, home service supervisor of the Georgia Power Co., presented a paper with the title "Introducing Garden Lighting Fashions in Atlan-

Delegates from Canadian Sections and Chapters of the Society totalled 61 members. Here some of them are grouped in the Commodore lounge.

Residence Lighting experts demonstrate "keys" to successful operation of Residence Lighting Forums. Seated: Emily Alexander, Mary Taepke; standing: Kerr Sanders, Jan Reynolds, May Love Gale, Virginia Skinner and Edith Buchholtz.

Norma Vacha (Cleveland Section) receives the Regar Cup from President Strong. Gene Beggs, Chairman of the Golf Contest, is at right.

ta." As a means of gaining experience with garden lighting techniques and materials, the Atlanta Residence Lighting Forum planned a spring meeting on the subject of garden lighting, and did the actual lighting of a garden which was made available to them.

The 1953 edition of the I.E.S. Recommended Practice for Residence Lighting, was introduced by Jan Reynolds of Sylvania Electric Products, Inc., chairman of the sub-committee of the Residence Lighting Committee which prepared it. Speaking for Mary Webber, home lighting specialist for the General Electric Company, for the past three years chairman of the Residence Lighting Committee, Miss Reynolds pointed out that the Practice has been completely rewritten since its last edition in 1947, and represents the first comprehensive recommendation for fulfilling the visual requirements of *family life* in the home, rather than merely *lighting the home*, in the abstract.

Social Program

Top social function in the Society is, of course, the annual President's Banquet. This was a brilliant affair held on the closing day, with 770 members and guests attending. As a closing ceremony, before turning the event over to dancing, Professor Everett M. Strong was presented with his Past-President's Pin, by incoming President A. Homer Manwaring, officially inaugurating the new administration.

A pleasant custom, started at the 1952 Conference, was continued this year, in arranging a special Past-Presidents' table at the Banquet, directly in front of the speakers' table. A standing ovation was given this distinguished group, who were:

Mr. & Mrs. S. G. Hibben
Mr. Walter Sturrock
Mr. & Mrs. C. H. Goddard
Mr. & Mrs. L. E. Tayler
Mr. & Mrs. A. F. Wakefield
Mr. S. B. Williams
Mr. & Mrs. Willard Brown
Mr. & Mrs. L. H. Graves
Mr. & Mrs. W. F. Little
Mr. H. H. Magdsick
Dr. Ward Harrison

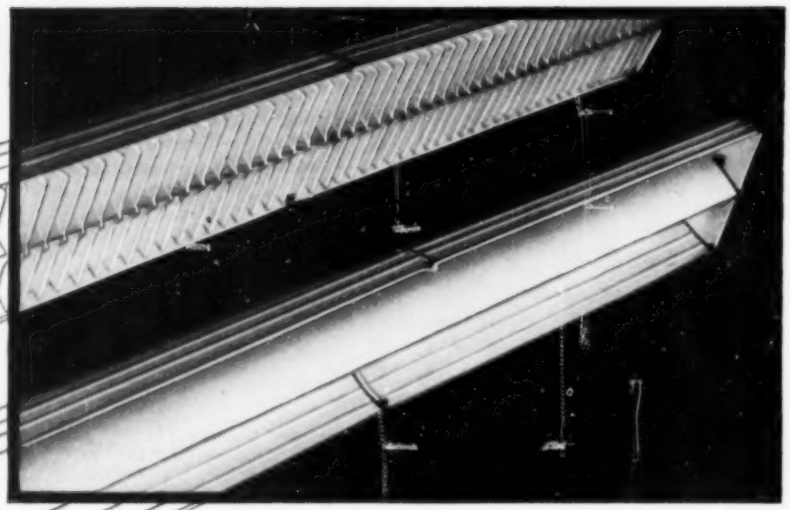
Another highlight of the social program was the "Mixer" party held the first evening, at which the New York Section was host. Almost the entire convention got dressed up to enjoy the more personal contact of a buffet and cocktail party.

New President A. H. Manwaring and Mrs. Manwaring in the receiving line at the President's Reception.

Table for Past-Presidents of the Society and their wives was located directly in front of the head table.

Sylvania Announces! A New Industrial-Commercial Fluorescent Fixture Line!

New Sylvania I-C Fixture with 45° x 45° louvered shielding



Showing I-C Fixture with "V" type reflector providing 45° crosswise shielding

Quality built and packed with these advanced features:

45° x 45° Louvered Shielding—Direct Glare is kept to a minimum when 45° x 45° louver shielding is used.

60% - 40% Distribution — Distribution from I-C fixtures is 60% downward and 40% upward, providing a strong direct component for high levels of illumination.

Versatile and rugged, too! — Channels are die-formed of 20-gauge steel. Made with extra knockouts to provide flexibility of installation. Designed for individual or continuous-row installations, pendant or surface mounting. Metal parts Bonderite treated to resist deterioration. Channels, louvers and steel panels finished in Sylvania's high-temperature baked Miracoat, providing 86% reflectivity.

T-17 Low Brightness Unit — The I-C line has been designed to accommodate the 40-watt 60-inch T-17 low-brightness lamp, meeting the need for a unit with minimum shielding. Combines low brightness, comfortable illumination with high efficiency and easy maintenance.

New from every angle!

● Now Sylvania comes forward with the new I-C series . . . the most sales-winning lighting fixture line ever offered.

It's another high quality Sylvania line, including today's most wanted features. Amazingly versatile, too, with 4, 5, and 8 foot units specifically designed to meet the lighting needs of offices, stores, schools and factories. Ideal for critical seeing tasks such as those encountered at printing plant composing stones or in the machining of specular metals.

And, it's a right-priced line offering new business opportunities to your architect, builder, and electrical-contractor friends . . . for both *industrial and commercial applications.*

Remember, this Sylvania I-C line is designed, built and tested and *fully guaranteed* for one year by Sylvania. For detailed information see your Sylvania representative or write directly to: Sylvania Electric Products Inc., Dept. 3X-3011, 1740 Broadway, New York 19, N. Y.

SYLVANIA

LIGHTING • RADIO • ELECTRONICS • TELEVISION

In Canada: Sylvania Electric (Canada) Ltd.
University Tower Building, St. Catherine Street, Montreal, P. Q.

Industry Women's luncheon attended by 28 women active in the lighting industry and registered at the Conference was held Thursday noon.

An "industry women's" luncheon was another interesting feature, Thursday noon. About 28 lady executives active in the lighting industry held a luncheon party, organized by Jan Reynolds of Sylvania Electric Products. Women from many parts of the country participated in this.

Ladies' Program

The 259 ladies accompanying delegates to the conference had a special program of their own, under the direction of Jan Reynolds as Chairman. In addition to the Banquet, and the Mixer party, trips were arranged to the United Nations, and around Manhattan in a sight-seeing boat. Fifth Avenue shops and Broadway shows offered scant competition, judging from the attendance at these excursions.

A "kaffee-klatsch" get-together was held each morning for the ladies in one of the larger parlors of the Commodore Hotel. The gathering served as a starting point, meeting place and a fine opportunity to make new friends. Mrs. George J. Taylor, wife of the Northeastern Regional V-P was hostess. Mrs. Taylor was assisted by: Mrs. R. C. Kinney, Mrs. R. M. Zabel, Mrs. S. F. Hauser, Mrs. J. D. Hall, Mrs. C. E. Ellis, Mrs. M. N. Waterman, Mrs. L. T. Johnson, Mrs. A. L. Dougherty, Mrs. S. H. Hazelton, Mrs. H. Chippendale, Mrs. Matt Veeck and Mrs. E. M. Rambusch.

Membership Prizes

President Strong awarded checks to representatives of winning Sections and Chapters in this year's Membership Campaign, during the Banquet ceremonies.

First prize for Group I went to the Northern California Section, Dan Finch accepting the check.

Roy Dahlin, outgoing Chairman of the Southern California Section which placed second in the membership race in Group I, is congratulated by President Strong.

Group II winner was the St. Louis Section, for whom Lee Wallace accepted the award.

Group III had Indiana Chapter first and Arizona Chapter second. Group IV was won by the Mid South Chapter, with New Mexico a close second.

Travel Gavel

The gavel and anvil, awarded for membership times miles traveled to the Conference, has itself traveled only from, and back to New Orleans these past three years. New Orleans won it again, as in 1951 and 1952. Ten of their members traveling to New York did the trick. Toronto Section was second with 39 delegates, Chicago third with 58.

If this seems confusing, it should be noted that the gavel award is based on the largest attendance present in percentage of the total Section membership, times the miles traveled. Fifty of the Society's 63 Sections and Chapters were represented in the Conference attendance.

Golf Award

Another trophy keenly contested is the I.E.S. President's Cup, also known as the Law Trophy. Marty Boettinger, Toledo, almost a perennial winner of this contest again carried away the Law Trophy. This silver cup was presented to the Society by Clarence L. Law, President in 1923-1924, and is placed in competition at each Conference on an 18-hole handicap basis.

The Regar Cup, which has been in competition since 1937, was accepted by Norman Vacha for the Cleveland Section. The Regar Cup is a gift of the late G. B. Regar, President in 1936-1937.

Kaffee-klatsch held each morning brought ladies together for visiting and planning. Mrs. George J. Taylor, second from right, was chairman. From here they embarked on a day's activities of sight-seeing and social events.

The Receiving Line at the President's Reception: left to right are Mr. and Mrs. C. C. Keller, Mr. and Mrs. Kirk Reid, Mr. and Mrs. R. F. Hartenstein, Mr. and Mrs. D. M. Jones, Incoming President and Mrs. A. H. Manwaring and President and Mrs. E. M. Strong.

Presidential hand-shake. Incoming National President A. H. Manwaring and retiring President E. M. Strong greet each other.

A Past-Presidents' luncheon on Wednesday brought together twelve past-presidents of I.E.S. as guests of Incoming President A. H. Manwaring:

Willard C. Brown	H. H. Magdsick
L. H. Graves	Prof. E. M. Strong
Charles H. Goddard	Walter Sturrock
Dr. Ward Harrison	L. E. Tayler
Samuel G. Hibben	A. F. Wakefield
W. F. Little	S. B. Williams

Southwestern Regional V-P M. J. Myers, Jr., and Mrs. Myers.

In the ladies' golf contest, Mrs. Eugene Beggs took low net, low gross and team championship — as the sole contender.

Incidental Items

The Auditors and Controllers Convention was in business on the same floor as I.E.S. at the Commodore. Two ladies from their Convention registered at I.E.S., bought banquet tickets and received a complete folder of I.E.S. literature. Thoroughly fouled up the registration records of both conventions.

George Stickney, elder statesman, Charter member and Past-President of I.E.S. attended the opening session of the Conference. A sad report, however. Mrs. Stickney who was with him in New York, passed away September 20, a few days after the Conference closed.

Committee meetings went on at all hours during the week of the conference. Making the most of the presence of out-of-town members were: Publications Committee, Office, Light Control, Nomenclature, Papers, Research Fund, Study Projects in Industry, National Defense, C.I.E. Papers, Lighting Service, Residence Lighting Forum, Education, Public Buildings, Daylighting, Local Activities, Sustaining Membership, Color & Illumination, School, Q & Q, Street and Highway and Store Lighting Committees.

Most of these meetings were breakfast meetings or in the late evening.

New York Section compiled a mimeographed list of lighting installations to see in New York, distributed to all delegates.

Advance purchase of Preprints was apparently a popular procedure. Not a copy was to be had by the end of the week.

Bob Blatt of *Electrical World* was about the busiest man at the Conference, taking pictures by the dozens.

Where Credit is Due

As many members know who have conducted Regional and National Conferences, organized effort by many people is required for a meeting such as this one. Credit is due the following, for the smooth operation of the New York Conference:

Conference Executive Committee

Chairman — Clarence C. Keller, Holophane Company, Inc.

Vice-Chairman — Ernest H. Salter, Electrical Testing Laboratories, Inc.

Secretary — A. D. Hinckley, Illuminating Engineering Society

Vice-President Northeastern Region — George J. Taylor, Day-Brite Lighting Inc.

Chairman New York Section — M. N. Waterman, Westinghouse Electric Corp.

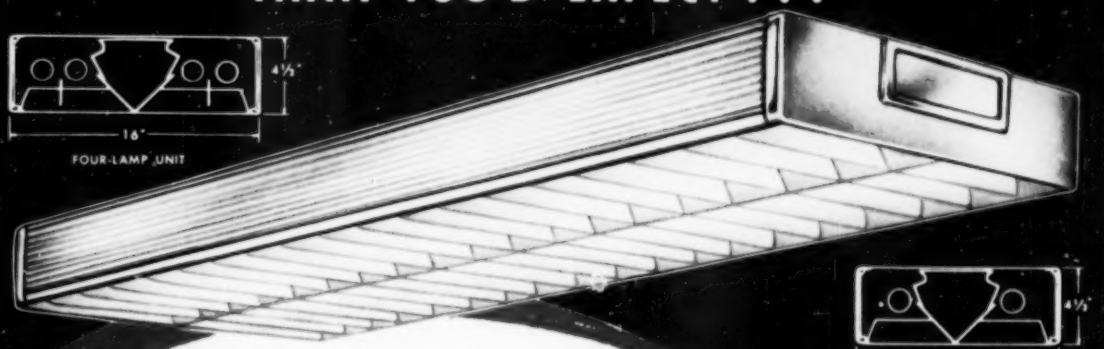
Sub-Committee Chairmen

Douglas H. Baker	Edward Ramsbusch
Eugene W. Beggs	Miss Jan Reynolds
Robert C. Blatt	George J. Taylor
Arthur H. Brooke	J. B. Spillane
Berlon C. Cooper	Matthew A. Veeck
William G. Morrison	

(Continued on page 14A)

Dr. D. B. Harmon, Austin, Texas, chats with George Taylor, Northeastern Regional V-P.

SO MUCH MORE UTILITY THAN YOU'D EXPECT . . .



IN A LUMINAIRE OF SUCH RADIANT *Beauty*

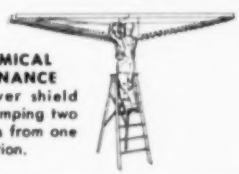
GARCY *Starliner*

OVER 80% EFFICIENCY • 30° x 40° Shielding
. . . yet only 4½" Deep

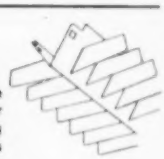
Slim, trim and functional in appearance, the Garcy Starliner lends itself beautifully to contemporary styling. When surface mounted, its shallow contour economically simulates built-in lighting. Yet within its compact design, this luminaire embodies every wanted feature. Side panels of Corning's Alba-lite glass are attractively framed in protective metal rails . . . promote efficient light distribution while contributing to proper brightness control. Garcy's louver design provides 30° x 40° shielding. The Starliner is superbly made . . . note the round edges on end plates and side rails. Economically installed, easily maintained. Available as two-lamp or four-lamp units in 4 ft. or 8 ft. lengths for standard fluorescent, rapid start or slimline lamps. Write for Bulletin L-134.

FAST, LOW-COST INSTALLATION
with Garcy Sliding Clamp Hangers for easy alignment, both vertically and horizontally. Adjustable in height by simply turning stem.

ECONOMICAL MAINTENANCE
Single louver shield permits relamping two 8 ft. fixtures from one ladder position.



STURDY CONSTRUCTION
V-shaped backbone securely holds louver cross-fins under spring tension . . . prevents looseness, rattle or "sing."



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(*Continued from page* 12A)

NATIONAL TECHNICAL CONFERENCE COMMITTEE 1952-1953

Responsible for the general coordination of all conference activities including all plans and budgets, and in cooperation with the Papers Committee for the satisfactory allocation of time for the Technical Papers Sessions.

Chairman — Hoyt P. Steele
Benjamin Electric Mfg. Co.

C. L. Amick	Clarence C. Keller
G. F. Dean	Lee E. Tayler
J. C. Forbes	George J. Taylor
R. F. Hartenstein	A. S. Turner
Paul H. Hildebrand	M. N. Waterman
A. D. Hinckley	R. M. Zabel

PAPERS COMMITTEE 1952-1953

Responsible for the procuring, review and approval of all technical papers and discussions thereof, for presentation before National Technical Conferences of the Society.

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Westinghouse Electric Corporation
Vice-Chairman, L. E. Barbrow
National Bureau of Standards

L. J. Buttolph	C. N. Laupp
C. L. Cottrell	W. P. Lowell, Jr.
George Gilbeard	G. A. Trosper
B. F. Greene	H. L. Wright

LIGHTING SERVICE COMMITTEE 1952-1953
Responsible for conducting a Lighting Service Forum in connection with the National Technical Conference of the Society.

Chairman — L. E. Tayler
Detroit Edison Company

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Roy A. Palmer	F. C. Winkler

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Sylvania Electric Products Inc.

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Mrs. Eugene W. Beggs	Mrs. R. C. Kinney
Mrs. Robert C. Blatt	Mrs. William F. Little
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Mrs. James D. Hall	Mrs. George J. Taylor
Miss Lucy L. Hanan	Mrs. R. F. Townsend
Mrs. S. F. Hauser	Mrs. Matthew A. Veeck
Mrs. S. H. Hazleton	Mrs. M. N. Waterman
Mrs. Samuel G. Hibben	Mrs. Eleanore Weise
Miss Caroline E. Horn	Mrs. R. M. Zabel
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Mrs. Leon T. Johnson	

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Victor G. Fucigna	Miss Winonah Murphy
Walter H. Garrett	Daniel J. O'Neill
Miss Geraldine Grant	Ferdinand C. Sasso
Herbert S. Hartley	

Technical Program

National Officers Report

Monday Morning, September 14th
Grand Ballroom
Chairman — Hoyt P. Steele

Benjamin Electric Mfg. Co., Des Plaines, Ill.
Light's Diamond Jubilee — Walter Sammis, President Ohio Edison Company, President Edison Electric Institute 1953-1954.
The General Secretary Reports — C. C. Keller, Holophane Company, Inc.
President's Address — E. M. Strong, Cornell University.
Our Society in 1953-54 — A. H. Manwaring, Philadelphia Electrical & Mfg. Co.
Presentation of Fellows in 1953 — President Strong.
Announcements by Chairman, Conference Executive Committee — C. C. Keller, Holophane Company, Inc.

Light and Vision

Monday Afternoon, September 14th
Grand Ballroom
Session Chairman — R. M. Zabel
Westinghouse Electric Corp.

Visual Fatigue with Special Reference to Lighting — H. C. Weston, Director of Group, Research in Occupational Optics, Institute of Ophthalmology, University of London; Secretary of Vision Committee, Medical Research Council.

Visual Factors in Lighting — W. S. Stiles O.B.E., D.Sc., Department of Scientific and Industrial Research, National Physical Laboratory, Teddington, Middlesex, England.

Discussion
H. R. Blackwell, Director, Vision Research Laboratory, University of Michigan.
Glenn A. Fry, Director, School of Optometry and Co-Director, Institute for Research in Vision, Ohio State University.
S. K. Guth, In Charge of Research, Lamp Division, Application Engineering Dept., General Electric Co., Cleveland, Ohio.
Harry Helson, Dept. of Psychology, University of Texas.
Ward Harrison, President, Commission Internationale de l'Eclairage.

Light Sources and Controls

Tuesday Morning, September 15th
East Ballroom
Session Chairman — L. J. Buttolph
General Electric Company
Discussion Organizer — E. H. Raddin
Champion Lamp Works

Dimming Hot Cathode Fluorescent Lamps — J. H. Campbell and H. E. Schultz, General Electric Co., Cleveland.
W. H. Abbott, General Electric Co., Ft. Wayne.

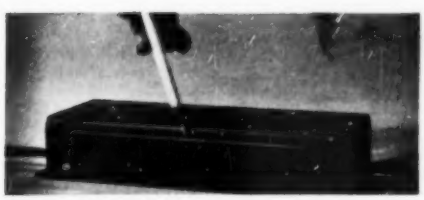
(*Continued on page* 17A)

Next Year's Conference Paper Outlines Due January 15

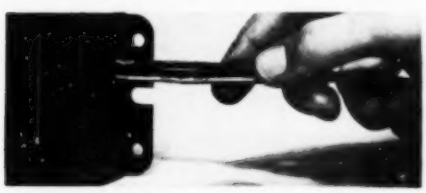
If you plan to present a paper at the 1954 National Technical Conference in Atlantic City, NOW is the time to prepare your outline. All outlines for 1954 Conference papers must be in the hands of the Papers Committee no later than January 15, 1954. Send them to: Dr. R. M. Zabel

Papers Committee Chairman
Westinghouse Electric Corp.
Bloomfield, New Jersey.

Here's progress you can measure in fluorescent ballast design



IMPROVED HEAT CONDUCTION is assured when side panel is mounted in contact with channel metal.



EASIER MOUNTING is possible because of new location of leads, out of the way of mounting tools.

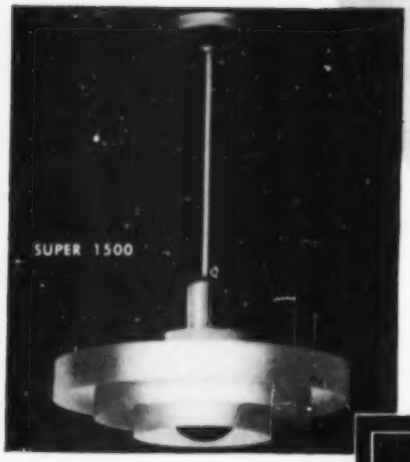
Lighter by half a pound and only $1\frac{3}{4}$ in. high . . . that's progress in fluorescent ballast design. These G-E two-lamp, 40-watt rapid start and standard switch-start ballasts assure both easier handling and far more compact and economical fixture design. You can count on sizeable savings in handling and shipping costs on mass production runs.

MORE EFFICIENT DESIGN gives you better ballast operation, too. For example, the long panels on either side of this new ballast case permit rapid heat dissipation into fixture channel metal when ballast is properly mounted.

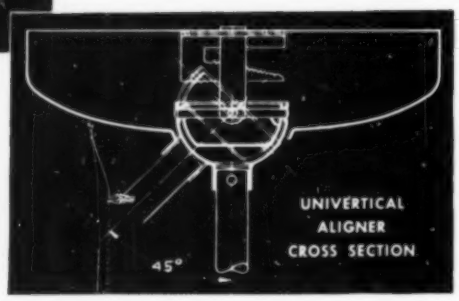
NEW LEAD LOCATION makes mounting easier. Half way between center mounting slot and corner mounting holes, leads can't interfere with mounting operations.

FOR BETTER FIXTURES that are smaller, more convenient, easier to install and handle, it will pay you to use G.E.'s new shallow-height brick case ballasts for two-lamp, 40-watt applications. Contact your nearest G-E Apparatus Sales Office or authorized G-E distributor today. General Electric Company, Schenectady 5, N. Y. 412-110

GENERAL ELECTRIC



Having trouble hanging lighting fixtures from sloping ceilings?



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SUCCESSFUL INSTALLATIONS IN

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prove . . .

the outstanding efficiency and economy of the combination of this concentric ring fixture and the silvered bowl lamp it uses. Perfect shielding of light source provides glareless, shadowless light. The Super 1500 is always recommended for critical lighting requirements.

This new, exclusive Silvray development is the easiest answer to the annoying, troublesome and time-consuming problem of vertical alignment of stem suspension fixtures from sloping ceilings. In single story buildings and in many schools, sloping ceilings are used to permit clerestory windows. The Silvray Super 1500 has been selected in many instances as the one unit that would provide perfect vertical alignment. A special, quickly adjusted mechanical device, concealed in the canopy, allows the unit to swing to an absolute vertical position on ceilings that slope up to 45°, and then securely locks the stem in place. No trouble . . . no tools.

*Patent applied for

SEND FOR COMPLETE DETAILS:

The complete facts about the Silvray Super 1500 Line . . . its efficiency, economy and adaptability are available upon request. Just fill in, clip and mail the coupon below.

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Gentlemen:

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FLOOR SERVICE MAINTENANCE

Easily and quickly accomplished by removing the silvered-bowl thru the fixture opening with a pole type lamp changer. The one shown operates on the vacuum principle and will handle lamps of from 75 watts to 1000 watts.

SILVRAY LIGHTING, INC.

RKO BLDG., RADIO CITY
NEW YORK 20, N. Y.

(*Continued from page* 14A)

Electrical Characteristics of Fluorescent Lamps and Ballasts — W. C. Gungle, Sylvania Electric Products Inc., Salem.
Cold Cathode Power Sources — R. Hultgren, CELine, Inc., St. Charles, Ill.
Some Applications of High Speed Motion Picture Photography to Lamp Manufacturing — I. S. Goodman, Westinghouse Electric Corp., Bloomfield.
Mercury Lamp Starting Requirements for Outdoor Applications — A. E. Binder, General Electric Co., Cleveland.

My Most Interesting Lighting Job Contest

Tuesday Afternoon, September 15th
East Ballroom
Chairman — Lee E. Tayler
Detroit Edison Co.

Judges:
C. L. Crouch, Technical Director, Illuminating Engineering Society
Lester H. Graves
Samuel G. Hibben, Westinghouse Lamp Division
William F. Little, Electrical Testing Laboratories, Inc.
Everett M. Strong, Cornell University.

Regional Winners:

Canadian	Lighting of a Church Benoit Doucet, Curtis Lighting of Canada Ltd.
East Central	Lighting of a Jewelry Store L. E. Spears, Pennsylvania Power Co., New Castle, Pa.
Great Lakes	Lighting an Executive Office Nick Stuffer, Westinghouse Electric Corp., Cleveland
Midwestern	Lighting of a Dress Shop Henry Koether, Wisconsin Electric Power Co., Milwaukee
Northeastern	Lighting of a Bank Directors' Room R. R. Duncan, Jr., New Bedford Gas & Electric Light Co., Mass.
Pacific Northwest	Lighting a Banking Room Don Frank, Columbia Electric & Mfg. Co., Spokane, Wash.
Southern	Floodlighting the Mississippi State Highway Headquarters Bldg. Mario G. Zervigon, L. N. Goodman & Associates, New Orleans, La.
South Pacific Coast	Lighting the Broadway Tunnel Merrill Humber, Humber & Walker Co., San Francisco, Calif.
Southwestern	Lighting a TV Tower E. J. Whitlow, McClure Electric Co., Dallas, Texas.

Lighting Progress—A Demonstration Report

Tuesday Evening, September 15th
Grand Ballroom
Chairman — Theodore C. Sargent
Sylvania Electric Products Inc., Salem, Mass.

Lighting Evaluation

Wednesday Morning, September 16th
East Ballroom
Session Chairman — W. P. Lowell, Jr.
Sylvania Electric Products Inc.
Discussion Organizer — Dean Farnsworth
U. S. Naval Submarine Base, New London, Conn.

Comparative Analysis of Comfort and Glare — D. E. Spencer, University of Connecticut.
The Orientation Reflex — H. L. Logan, Holophane Co. Inc., New York.
Maintenance of Industrial Lighting — C. E. Egeler, R. F. VandenBoom, General Electric Co., Cleveland.
Efficiency and Appearance Factors in Luminous Panels — M. E. Haskins, Jr., Westinghouse Electric Corp., Bloomfield, N. J.
Photographing Fluorescent Lighting Installations in Color — W. Allphin, Sylvania Electric Products Inc., Salem, Mass.

Utilization

Wednesday Afternoon, September 16th
East Ballroom
Session Chairman — B. F. Greene
Consulting Engineer
Discussion Organizer — D. M. Finch
University of California

Interflectance Tables from Conventional Photometric Data — L. E. Innis, Sylvania Electric Products Inc., Salem, Mass.
A Comparison of Measured and Calculated Coefficients of Utilization — J. R. Jones, Westinghouse Electric Corp., Bloomfield; J. J. Neidhart, Westinghouse Electric Corp., Cleveland, Ohio.
Measured Utilization Factors — W. M. Potter, A. H. Russell, General Electric Company, Cleveland, Ohio.
Rectangular Coordinate Photometer — for Large Area Luminaires — J. A. Losh, A. L. Smith Iron Co., Chelsea, Mass.

Street Lighting

Thursday Morning, September 17th
East Ballroom
Session Chairman — C. N. Laupp
Wisconsin Electric Power Co.
Discussion Organizer — F. D. Wyatt
Chicago Park District

The Development of Highway Lighting in Metropolitan Chicago and Northern Illinois — R. J. Seitz, E. M. Prins, Public Service Co. of Northern Illinois.
Light and Night Traffic Accidents — D. M. Baldwin, National Safety Council, Chicago.
Some Observations on Fluorescent Street Lighting Here and Abroad — Philip H. Houser, Rectifier Dept., General Electric Co., West Lynn, Mass.
Effect of Temperature on Fluorescent Street Lighting Luminaires — J. E. Bock, J. S. Franklin, General Electric Co., Lynn, Mass.
Street Lighting Photocell Control Calibration Cabinet — L. C. Edwards, W. N. Lindblad, Pacific Gas & Electric Co., San Francisco, Calif.

Residence Lighting Forums in Action

Thursday Morning, September 17th
West Ballroom
Chairman — Edith L. Buchholtz
Westinghouse Electric Co., Bloomfield, N. J.

Practical Lighting Features in Long Island Homes — Virginia Skinner, Home Lighting Director, Long Island Lighting Co.
Electrical Planning Includes Good Lighting — May Love Gale, Home Economist, Tennessee Valley Authority.
New Lighting Installations in and Around Chicago — Kerr Sanders, Chicago Lighting Institute.
Solutions to Lighting Problems Created by the New Architecture — Mary Taepke, Detroit Edison Company.
Introducing Garden Lighting Fashions in Atlanta — Emily Alexander, Georgia Power Company.
The Role of Residence Lighting Forums in the I.E.S. — Edith L. Buchholtz, Chairman, Residence Lighting Forums Committee.
Announcement of New Edition of "Recommended Practice for Residence Lighting" by Residence Lighting Committee Chairman, Mary Webber, General Electric Company.

Measurements

Thursday Afternoon, September 17th
East Ballroom
Session Chairman — H. L. Wright
Curtis Lighting of Canada Ltd.
Discussion Organizer — W. Allphin
Sylvania Electric Products Inc.

Effect of Ambient Temperature on the Light Output of Fluorescent Lamps — C. M. Holden, Champion Lamp Works, Lynn, Mass.
Effect of Temperature on Electrical and Color Parameters of 40T12 Fluorescent Lamps — C. W. Jerome, Sylvania Electric Products Inc., Salem, Mass.
An Instrument for the Evaluation of Night-Visibility on Highways — A. E. Simmons, D. M. Finch, University of California, Berkeley, Calif.
Design Characteristics of a Photo-Electric Brightness Meter — K. Freund, Photo Research Corp, Burbank, Calif.

Daylighting

Thursday Afternoon, September 17th
West Ballroom
Session Chairman — G. Gilleard
Curtis Lighting Inc.
Discussion Organizer — R. A. Miller
Pittsburgh Plate Glass Co.

Functional Toplighting with Glass Block — H. F. Kingsbury, W. H. Billhartz, R. W. McKinley, Pittsburgh Corning Corp., Pittsburgh.
Daylighting with a New Kind of Functional Skylight — R. A. Boyd, University of Michigan and J. L. Reid, Architect, San Francisco.
Daylighting with Plastic Domes — B. F. Greene, Consulting Engineer, New York.

Closing Session

Thursday Afternoon, September 17th
East Ballroom
Chairman — Hoyt P. Steele
Benjamin Electric Mfg. Co.

Report of the Committee on Resolutions — Chairman, S. G. Hibben, Westinghouse Electric Corp., Bloomfield, N. J.

Deadline January 1 for I.E.S. Gold Medal Nominations

January 1 is the closing date for receipt of nominations for the I.E.S. Gold Medal. Nominations for this, the highest award of the Society, are invited from all members for consideration by the Medal Award Committee.

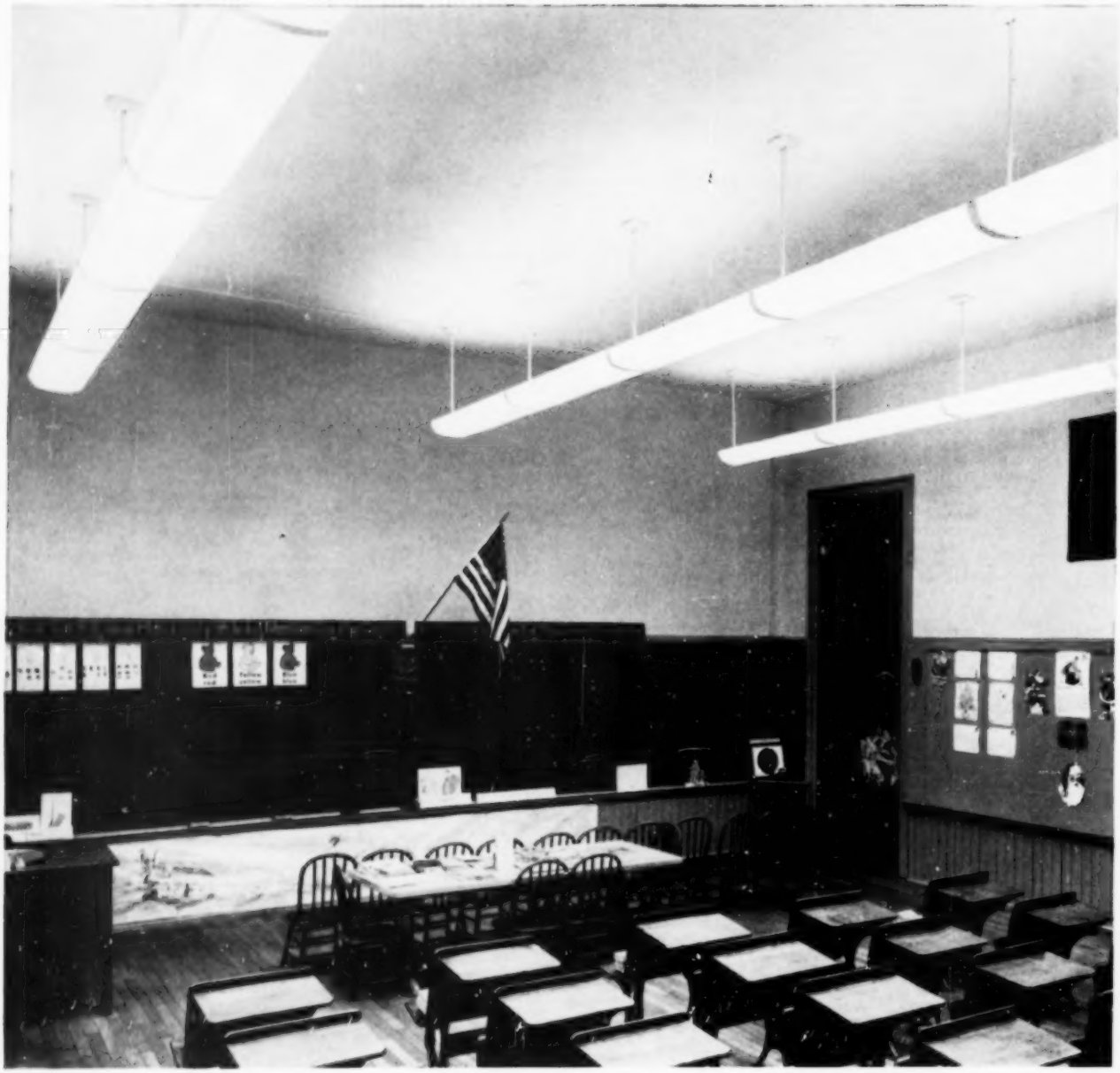
The Gold Medal is awarded to give recognition to meritorious achievement which has conspicuously furthered the profession, art or knowledge of illuminating engineering. The following points should be observed in making nominations for the Award.

(1) Candidates need not be members of the Society, nor citizens of the United States or Canada. Nominations may be made at any time by any member of the Society by presenting to the General Secretary at Society Headquarters the name of the individual whose accomplishments in his field are deemed worthy of such recognition — in the field of engineering, design, applied illumination, optics ophthalmology, lighting research, education, or administration and management.

(2) In order for a candidate to be considered for the award of a given year, a letter requesting consideration of the proposed candidate shall be delivered at the General Office of the Society before January 1 of that year.

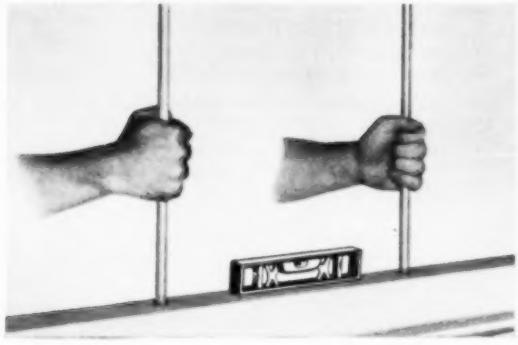
(3) Nominations and records on file in the General Office from previous years, as reviewed and referred to the next year's committee by the previous Medal Award Committee, will be given consideration along with new nominations.

(*Continued on page* 20A)



Look for this seal on your electrical contractor's guarantee. He installs them — we back him up.

The Westinghouse CD has steel channel and end plates; plastic sides and bottom are polystyrene extrusions.



This Westinghouse quick spin-level feature saves time. Merely place level on unit and adjust by rotating the stems to level the fixture.

by: Hugh S. James
Duquesne Light Company
Pittsburgh, Pennsylvania

"Eye comfort is No. 1 problem when modernizing old schoolrooms"

In modernizing the lighting for this three-story grade school in Clairton, Pa., we considered eye comfort above all other factors. High illumination levels with freedom from high brightness and glare was our objective.

To meet these specifications, we chose fluorescent well-shielded, semi-indirect fixtures—suspended two feet from the ceiling—to provide freedom from glare.

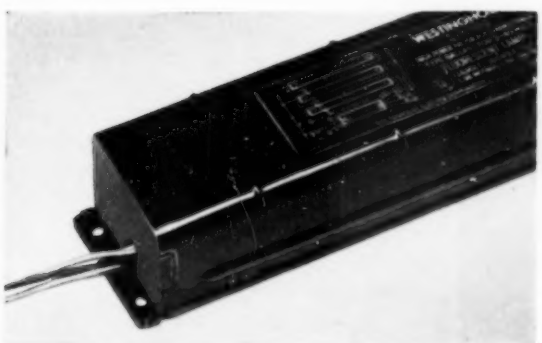
Chose Westinghouse CD Luminaires

The Westinghouse Type CD was most ideal for our purpose. It has translucent plastic sides and shielding, and emits just enough light to blend with the ceiling area. 72% of the light is directed up, making the entire ceiling area a low brightness light source. Initial footcandle readings on desk tops was 45. After six months, maintained illumination averaged 40 footcandles.

This plastic CD fixture is light, easy to handle, not easily broken and will not bend out of shape. Design is simple and well proportioned to room areas. It contains the new Westinghouse *lead-lag* ballast, which by test increases lamp life 10%. Unlike older series ballasts, the new *lead-lag* operates lamp circuits independently . . . which means simple relamping maintenance.

The contracting firm, Milan's Electric Sales and Service, used three men to install 107 of these Westinghouse CD fixtures *in a single day.* Careful advance planning, plus simple construction and ease of installation made this possible.

For your next school lighting job, consult Westinghouse. See or call your nearest Westinghouse representative, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. Ask for a copy of B-4566, *The ABC Plan for School Lighting.* J-04332A



New Westinghouse *lead-lag* ballast is now comparable to older series ballasts in weight and size—gives all other inherent features of *lead-lag* at no added cost.

YOU CAN BE SURE...IF IT'S
Westinghouse

(Continued from page 17A)

Three-Day Illumination Conference at U. of Wisconsin

As part of their highly progressive "Engineering Institutes" conducted the year round, University of Wisconsin Extension Division offered a comprehensive three-day course in illumination October 12, 13 and 14. The Illumination Institute was aimed particularly to the interests of architects, builders, consulting engineers and school and municipal officials.

Under the direction of Paul J. Grogan, Director of Wisconsin's Engineering Institutes, the curricula were as follows:

Designing Lighting for Today's Stores — Building Requirements vs. Footcandle Measurements, by Charles N. Laupp, Superintendent, Special Services, Sales Division, Wisconsin Electric Power Company, Milwaukee, Wis.

Specialized Lighting — The Trends Toward Lower Ceilings, by Albert Kurtzon, President, Alkco Manufacturing Co., Chicago, Ill.

Lighting Functions of Diffused and Prismatic Glasswares, by Clarence W. Clarkson, Lighting Consultant, Corning Glass Works, Chicago, Ill.

Part I — Mercury Vapor Lighting of Main Street with Demonstration of the Solution of Typical Lighting Problems.

Part II — A Uni-Ballast Mercury Vapor Series Circuit, by C. W. Puent, Street Lighting Product Sales Engineer, Line Material Company, Milwaukee, Wis.

A Practical Approach to Lighting Maintenance, by R. F. VandenBoom, Lamp Dept., General Electric Company.

Lighting Cost Analysis and New Lamp Sources by R. F. VandenBoom, General Electric Company.

New Developments in Industrial Lighting, by Howard W. Grosh, Lighting Application Engineer, Westinghouse Electric Corp., Milwaukee, Wis.

Industrial High Bay Lighting
(1) Distribution Curves
(2) Utilization Coefficients,
by E. H. Grieb, District Manager, Holophane Company, Inc., Wauwatosa, Wis.

The Economics of Various Present-day School Lighting Systems, by George Gilleard, Assistant Chief Engineer, Curtis Lighting Inc., Chicago, Ill.

Color Treatment of Schools, by B. H. Monroe, Manager, Paint Sales, Pittsburgh Plate Glass Company, Milwaukee, Wis.

I.E.S. Going Strong In La Crosse, Wisconsin

The group of I.E.S. members headed by Clinton L. Scuquist, Local Representative in La Crosse, Wisconsin, have been holding Section-like meetings there, with better than Section-like attendance. Their first meeting, September 28 had 85 people present, with good representation from a number of associated groups.

Subject of the meeting was "Light and Color" by L. E. Johnson, Chairman of the Twin City Section. Specially invited, and attending in gratifying numbers, were architects, consulting engineers, decorators, optometrists and physics teachers. In addition to Mr. Johnson, other representatives from the parent Section (Twin City) were R. E. Steele, past Chairman, D. R. Schwarz, Secretary, and Robert E. Olson.

A second meeting was held October 26 featuring "Light Sources" by Carl F. Jensen, Westinghouse Electric Corp., Chicago. The success of these two meetings has sparked a growing interest in lighting and in I.E.S. in the Wisconsin city, destined by the look of things to be the site of an active new Chapter.

"Operation I.E.S." — Educates Midwest Officers

About 60 Section and Chapter officers of the Midwestern Region and committee chairmen of the Chicago Section met in Chicago October 9 for an all-day "indoctrination" meeting in I.E.S. and local procedure. New officers from St. Louis, Milwaukee, Central Illinois and Chicago were present.

The program, organized as "Operation I.E.S." included a morning session featuring A. D. Hinckley, Executive Secretary of the Society, who described the structure, aims and procedure of I.E.S., and Ruby Redford, Editor of ILLUMINATING ENGINEERING, who outlined the Society's publication program. Keen interest in the subject kept headquarters personnel answering questions well into the afternoon.

Directing the meeting, held at the Chicago Lighting Institute, was J. R. Chambers, Chairman of Chicago Section.

Letter to the Editor — Footcandles vs. "Ez"

We were interested in the proposal made by "Lumeritas," the anonymous author of the Postscript page in the British *Light and Lighting* magazine, for a new term for footcandles (September 1953 I.E., page 6A).

"Lumeritas" proposes the term "Ez" and backs it up with reasoning which is a masterpiece of logic. I have one main objection to his proposed term, however: On my desk I use as a paper weight a 3-D "footcandle" (see cut). You can't very well use an "Ez" as a paper weight, now can you? — LUXAMERICANUS, *U.S.A.*

Three-Dimensional!

Electrical Contractors Open Fall Lighting Campaign

About 200 electrical contractors met in Philadelphia September 24 to inaugurate the Fall Lighting Campaign sponsored annually by the Electrical Association and the Philadelphia Electric Co. Highlight of the campaign is a cash prize contest sponsored by five electrical contractor groups: Independent Electrical Contractors Association, Penn-Del-Jersey Chapter of NECA, Delaware County Electrical Contractors Association, Contractors Division of the Electrical Association, and the Bucks-Montgomery Section of the Electrical Association. Contractors will win prizes for their outstanding achievements in four classifications of lighting: industrial, store, office and exterior.

Farm and Home Lighting — Topics for Full-Day Clinics

A full-day clinic on Farm Lighting and another on Home Lighting were presented at the Chicago Lighting Institute October 20 and 21. The sessions on Farm lighting were sponsored by the Institute in cooperation with the Chicago Section, I.E.S. and the Illinois Farm Electrification Council. The clinic on Home Lighting was sponsored by the Chicago Residence Lighting Forum of I.E.S., the American Home Lighting Institute, the Residence Lighting Fixture Committee of the Electric Association and the Chicago Lighting Institute.

Programs for the two clinics were:

FARM LIGHTING CLINIC

Morning Session: Chairman, Mrs. Van Aken Burns, Director of Home Economics Extension, University of Illinois.

Welcome — G. K. Hardacre, President, Chicago Lighting Institute.

Light Sources Used on the Farm — C. F. Jensen, Westinghouse Electric Corp.

Program Aids for Home Advisors — Mrs. Edith Huffman, Stevenson County Home Advisor.

New Ideas for Home Lighting — Edith L. Buchholtz, Residence Lighting Advisor, Westinghouse Electric Corp.

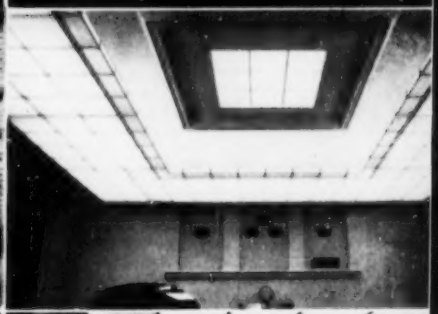
Telling the Story — Naomi Shank, Home Equipment Specialist, Iowa Extension Service.

Afternoon Session: Chairman, A. E. Becker, Manager, Association of Electric Cooperatives, Springfield.

Special Purpose Lamps — Ben Avery, District Lighting Engineer, General Electric Co.

(Continued on page 22A)

when the finest in lighting is specified...



Installations of Smithcraft Area Illumination the country over vary greatly as to size, pattern, shielding, periphery and shielding. And it's this *flexibility of design* that makes this advanced overall lighting system an important new architectural concept. All Smithcraft Area Illumination installations have these things in common: superb quality of illumination; functional integration with the building structure; ease and efficiency of installation and maintenance.

Reading from left to right, starting at top

The Mennen Company, Morristown, New Jersey
Owens-Corning Fiberglas Corp., Ashton, Rhode Island
Ford Motor Company, Dearborn, Michigan
Melbourne National Bank, Melbourne, Florida
Niagara Mohawk Power Corp., Syracuse, New York
Rawding Electric Company,
Beaver Falls, Pennsylvania
Texas Eastern Building, Shreveport, Louisiana
Mount Healthy-Saving and Loan Company,
Mt. Healthy, Ohio
Van Huffel Tube Corporation, Warren, Ohio
Florida Power and Light Company, Sanford, Florida

smithcraft area *illumination*

Ask us to send you our also useful giving further information on Smithcraft Area Illumination.

Smithcraft
LIGHTING DIVISION
CHELSEA 50, MASSACHUSETTS

(Continued from page 20A)

Application of Light to Plant Growth and Insect Control — Prof. Herbert Beresford, Head of Agricultural Engineering Dept., Iowa State College.
Where Do We Go from Here? — L. C. Groat, Manager, Spoon River Electric Cooperative, Canton.

HOME LIGHTING CLINIC

Morning Session: Chairman, Mrs. Robert Meany, President, Chicago Region of Illinois Congress of Parents and Teachers.
Welcome — Martha Brandt, Director of Home Economics, Commonwealth Edison Co.
New Developments in Light Sources — Sam Eaton, Assistant District Manager, Sylvania Electric Products, Inc.
Why Ceiling Fixtures and Brackets? — Edith L. Buchholtz, Residence Lighting Advisor, Westinghouse Electric Corp.
Today's Trends of Built-In Lighting — Kerr Sanders, Chicago Lighting Institute.
Design Factors of Floor and Table Lamps — Aileen Page, Home Lighting Specialist, General Electric Co.
Afternoon Session: Chairman, Marianne Willisch, Lecturer, Institute of Design, Illinois Institute of Technology.
Color's Part in the Picture — Jan Reynolds, Home Lighting Consultant, Sylvania Electric Products, Inc.
We Fit the Parts Together — Edith L. Buchholtz, Aileen Page and Jan Reynolds.
The Pathway to a Bright Future — Lois Fetherston, Architect and Past Chairman of the Chicago Residence Lighting Forum.

Both clinics were held at the Chicago Lighting Institute; registration fee for each conference was $3.00.

New Publication Available To Advanced Engineering Students

A new publication, to be circulated free to senior and graduate students working toward degrees in engineering and industrial sciences, is being planned by Industrial Laboratories Publishing Co., Chicago. The magazine, known as *Industrial Science and Engineering*, Advanced Student Edition, states as an editorial policy: the presentation of news and other informative material of immediate interest and value to senior and graduate students in engineering and the physical sciences.

Typical topics for feature articles planned are:

How to prepare for a career in research-development;
Technical education and selling as a career;
Why membership in professional societies is a "must" for technical men;
The language of industrial science;
Areas of specialization in industrial science and engineering.

Qualified students, Deans of Engineering and Chairmen of engineering science departments in recognized educational institutions are invited by the publisher to request the magazine. It is available to others by subscription only, at $25 a year. Publisher is Frank D. Thompson, Industrial Laboratories Publishing Co., 201 North Wells Street, Chicago 6, Illinois. George A. Whittington is Editor.

Job Placement for Engineering Veterans

The Engineering Manpower Commission of the Engineers Joint Council is continuing its program of advising engineers leaving the service and looking for placement to contact the placement bureau at their college and/or the Engineering Societies Personnel Service, Inc. at one of the following addresses:

8 West 40th St., New York, N. Y.
84 East Randolph St., Chicago, Ill.
100 Farnsworth Ave., Detroit, Mich.
57 Post St., San Francisco, Calif.

Companies interested in these engineers are encouraged by E.M.C. to maintain up-to-date listings at E.S.P.S. and college placement bureaus.

Pacific Northwest Region Has Own Membership Contest

The British Columbia Section has challenged the rest of their Region (Pacific Northwest) to a membership race. They have prepared a Shield to be awarded annually, at each Regional Conference, to the Section or Chapter within their Region to show the greatest increase in membership from October Council to April elections. First winner will collect its shield at the Regional Conference in Seattle next April 22-23, and hold the trophy until the following year. Decision of the umpire (Regional V-P) is final.

Paul Donnelly, Chairman of the B. C. Section's Membership Committee, has been appointed Chairman of the "PNW Membership Competition Committee."

Illumination and Seeing Course Sponsored by Mid-South Chapter

An eleven-session course on Illumination and Seeing is being sponsored by the Mid-South Chapter of I.E.S. in cooperation with the University of Tennessee. The three-hour classes, held on Thursday evenings beginning October 8 at the University, covered the following topics:

Theory of Light; The Eye; Partnership of Light and Sight.
Illumination Terms; Laws; Controls; Systems; Meters.
Electric Filament Lamps; Mercury Lamps; Glow Lamps; Fluorescent Lamps.
Illumination Design — Lumen Method (Parts I and II).
Effects of Light on Seeing.
Industrial Lighting.
Office and School Lighting.
Store Lighting; Exterior Lighting.
Residential Lighting; Fundamentals of Home Wiring.
General Review.

The I.E.S. members who are instructors for the course, each in his own specialty, are: Fred Niell, lighting engineer, Memphis Light, Gas and Water Division; Dr. O. N. Cole, optometrist; E. W. Schoenherr, district engineer with General Electric Lamp Division; Dr. M. E. Broom, dean of Southern College of Optometry; John Gilchrist, sales engineer with General Electric Lamp Division, who as Chairman of the Chapter's Lighting Education Committee acted as Coordinator.

Tuition for all eleven sessions was $18.

Regional Activities Committee Holds First Meeting

A new name was established for the important I.E.S. Committee formerly known as the Local Activities Committee, at Council meeting October 8. Now called the Regional Activities Committee, the group met October 9 to draw up major plans for the year. Personnel of the committee is the ten Regional Vice-Presidents of the Society under the direction of R. F. Hartenstein as chairman.

In addition to a review of Regional Vice-Presidents' duties, the committee discussed important Regional affairs such as: Board of Nomination Procedure; Fellow Nomination; Lighting Contest; Regional Conference dates; Advance Planning recommendations; Local Representatives and a number of other matters.

New England Section Sponsors Lighting Course

Five weekly classes in Illumination Fundamentals were held October 6 through November 3, sponsored by the I.E.S. New England Section, in cooperation with the Lighting Bureau of Electric Institute of Boston. Stressing fundamentals required for a knowledge of commercial, industrial and residential lighting, the course attracted large numbers of architects, contractors and utility salesmen in the Boston area.

Chairman for the weekly sessions was Arthur M. Bjontegard, General Electric Co., who is education chairman for the New England Section. "Faculty" members for the course included H. A. Breeding, General Electric, Lynn, Mass.; H. C. Finney, Westinghouse, Boston; R. R. Wylie and R. G. Slauer, Sylvania, Salem, Mass.; and L. S. Cooke, General Electric Co., Boston.

A fee of $2.00 to I.E.S. members and $4.00 to others was charged for the course, with certificates awarded to those completing it.

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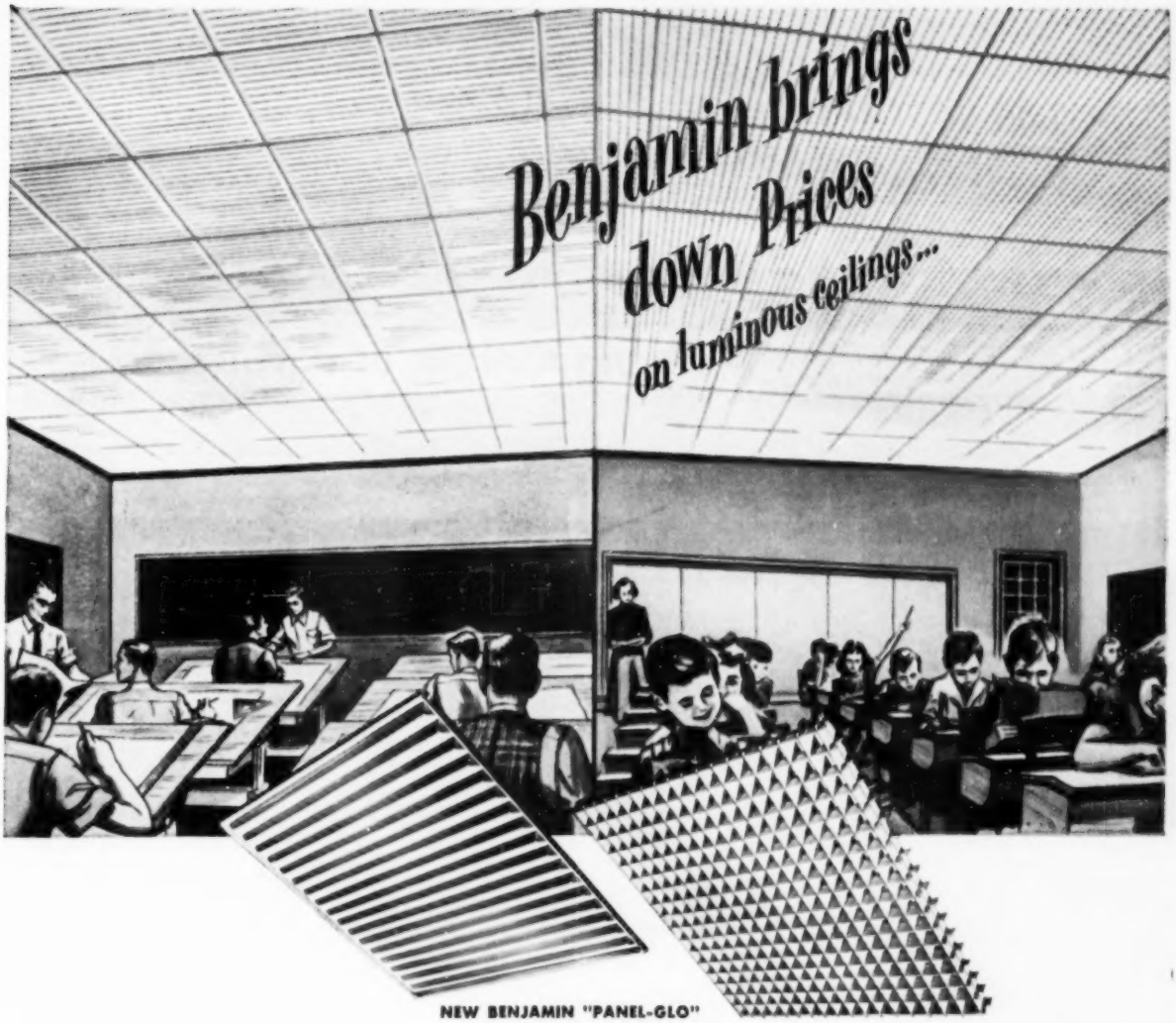


NEW BENJAMIN "PANEL-GLO"
cuts former Benjamin Price for ceiling louvers by as much as 50%!

NEW BENJAMIN "SKY-GLO"
Louvers now priced approximately 33⅓% less!

2 Great Advancements Insure Quality Lighting to Benjamin's High Standards at New Lower Prices!

New low prices and all-around simplification of Benjamin luminous ceiling lighting enable you to have ceiling lighting in all types of schoolrooms at a lower-than-ever installed price. Benjamin "Sky-Glo" and "Panel-Glo" represent a brand-new approach to ceiling lighting for classrooms, drafting rooms, laboratories, and other schoolrooms where high-level, diffused light is especially important. Here is lighting that is engineered for simple, low-cost installation . . . designed for high-level, well-diffused lighting quality, featuring the maximum seeing comfort always associated with Benjamin *translucent* ceiling lighting.
Send for Free "Sky-Glo" and "Panel-Glo" Data Bulletin.
Benjamin Electric Mfg. Co., Dept. I, Des Plaines, Illinois.

NEW Simplicity brings down installed price!
New, practical, easy-to-handle 3' x 3' translucent panels or louver sections.

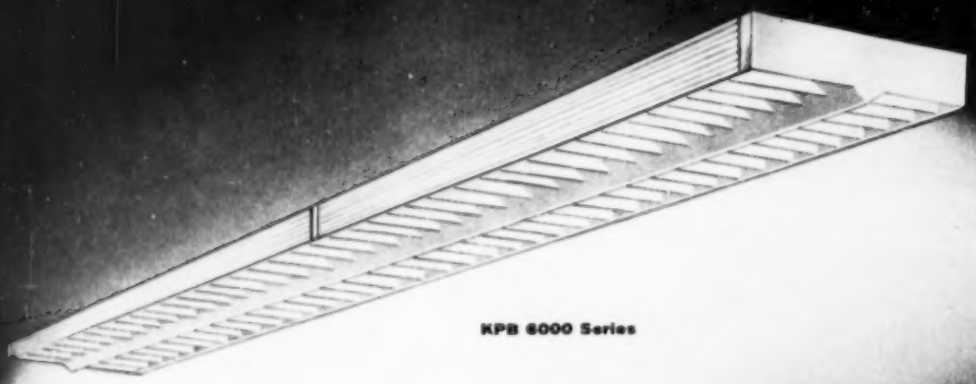
NEW, Easier installation brings down installed price!
No need to order "fill-in" size panels. Trim them yourself with scissors . . . right on the job . . . to the exact shape desired!
New metal FINISHING STRIPS neatly hide trimmed edges on either louver or luminous-panel jobs.

NEW, proven TRANSLUCENT plastic material means MORE LIGHT with CONTROLLED BRIGHTNESS.
(Same material used for "Sky-Glo" and "Panel-Glo.")

NOW, figure the complete price of a ceiling-lighting job by the sq. ft.!
Sq. ft. price includes all panels or louver sections as well as all the channels, fittings, etc. you need to complete the installation!*
No calculating, no figuring . . . just know the area of the room!
No layouts necessary for regularly-shaped rooms.
*lighting equipment not included.

BENJAMIN *Lighting Equipment*
sold exclusively through electrical distributors
B173S

no margin of darkness



KPB 6000 Series

Total luminosity of side panels from bottom edge to ceiling line is a glowing contemporary feature of Globe's new shallow depth, semi-direct luminaire.
Metal retaining rails are discarded. Diffuse plastic side panels are made self-rigid by molded lip extrusions.
Other advantages include: more diffused downward component--up to 35° X 35° lamp shielding--18 gauge steel louvres--easy lamping.
Available in 2 and 4 lamp design and for all commercial lamp classes.
Write for complete illumination, construction and installation data.

GLOBE LIGHTING PRODUCTS INC. Los Angeles 7: 2121 South Main Street
Brooklyn 6: 1710 Flushing Avenue

(Continued from page 22A)

Portable Lamp Panel Held by New York Residence Lighting Forum

New York architects, interior designers and lighting consultants, participated in a most valuable panel discussion October 21, on Portable Lamps. The meeting, held at the Architectural League, was sponsored by the I.E.S. Residence Lighting Forum, New York Section.

The fact-packed discussion covered the purpose, potentialities, positioning, design, selection and optimum use of portable lamps.

Prof. Everett M. Strong, last year's I.E.S. President, acted as Moderator.

Paul Schweikler, Department of Architecture at Yale University analyzed the importance of portable lamps in modern living.

C. L. Crouch, Technical Director of I.E.S., discussed aspects of lamp design affecting vision.

Gilbert Switzer, Design Critic, Yale University, reviewed that college's recently-completed Student Research Project concerning lamps having bare bulbs, tubular light sources, multiple bulbs, diffusing glass bowls and built-in reflectors.

These semi-formal presentations were followed by a panel discussion covering I.E.S. Recommended Practice, light sources, decoration, new material, lamp design and product development. Panel authorities were:

Caroline Horn, Engineering Assistant, Electrical Testing Laboratories.
Marshall Waterman, Commercial Engineering Dept., Westinghouse Lamp Division.
Gladys Miller, Decorator-consultant.
Greta Daniels, Ass't Curator, Dept. of Architecture and Design, Museum of Modern Art.
Edison Price, Lighting Equipment Engineer.
William F. Blitzer, Engineer in charge of Product Development, Lightolier, Inc.
Morris Thau, President, Mutual Sunset Lamp Manufacturing Company.

LIGHTING CALENDAR

Society Events

December 10, 1953—Meeting of I.E.S. Council, New York, N. Y.

February 11, 1954—Meeting of I.E.S. Council, New York, N. Y.

April 8-9, 1954—Southern Regional Conference, Roosevelt Hotel, New Orleans, La.

April 11-13, 1954—Southwestern Regional Conference, Rice Hotel, Houston, Texas.

April 15-16, 1954—Inter-Mountain Regional Conference, Denver, Colo.

April 19-20, 1954—South Pacific Coast Regional Conference, Museum of Art, San Francisco, Calif.

April 22-23, 1954—Pacific Northwest Regional Conference, Benjamin Franklin Hotel, Seattle, Wash.

April 28-30, 1954—Canadian Regional Conference, King Edward Hotel, Toronto, Ont.

May 3-4, 1954—Great Lakes Regional Conference, Sheraton-Cadillac Hotel, Detroit, Mich.

May 17, 1954 (Week of, one day)—Northeastern Regional Conference, Hartford, Conn.

June 17-19, 1954—Midwestern Regional Conference, Jefferson Hotel, St. Louis, Mo.

September 12-16, 1954—Illuminating Engineering Society, National Technical Conference, Chalfonte-Haddon Hall, Atlantic City, N. J.

Industry Events

November 2-6, 1953—American Institute of Electrical Engineers, Fall General Meeting, Muehlebach Hotel, Kansas City, Mo.

November 9-12, 1953—National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

November 16-20, 1953—National Electrical Contractors Association, Miami Beach, Fla.

November 29 - December 4, 1953—The American Society of Mechnical Engineers, Annual Meeting, Statler Hotel, New York, N.Y.

December 2-3, 1953—Commercial Lighting Committee, Edison Electric Institute, Detroit, Mich.

December 2-4, 1953—National Association of Manufacturers, Annual Convention, Waldorf-Astoria Hotel, New York, N. Y.

December 3-4, 1953—Home Service Committee, Edison Electric Institute, Indianapolis, Ind.

January 11-14, 1954—National Rural Electric Cooperative Association, National Convention, Miami, Fla.

January 18-22, 1954—American Institute of Electrical Engineers, Winter General Meeting, New York, N. Y.

January 25-28, 1954—Plant Maintenance & Engineering Show, International Amphitheatre, Chicago, Ill.

March 8-11, 1954—National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

May 3-7, 1954—Society of Motion Picture and Television Engineers, Semi-Annual Convention, Hotel Statler, Washington, D. C.

May 13-14, 1954—Public Utilities Advertising Association, National Convention, Hotel Statler, Boston, Mass.

June 6-11, 1954—National Association of Electrical Distributors, 46th Annual Convention, Atlantic City, N. J.

June 21-25, 1954—American Institute of Electrical Engineers, Summer General Meeting, Los Angeles, Calif.

September 22-24, 1954—Canadian Electrical Manufacturers Association, General Brock Hotel, Niagara Falls, Ont., Canada.

October 11-15, 1954—American Institute of Electrical Engineers, Fall General Meeting, Chicago, Ill.

October 18-22, 1954—42nd National Safety Congress & Exposition of the National Safety Council, Chicago, Ill.

October 18-22, 1954—Society of Motion Picture and Television Engineers, Semi-annual Convention, Los Angeles Ambassador, Los Angeles, Calif.

November 8-11, 1954—National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

November 28 - December 3, 1954—The American Society of Mechanical Engineers, Annual Meeting, Statler Hotel, New York, N.Y.

Optical Society Convenes For 3-Day Meeting in Rochester

Most recent advancements in optics and the role it is playing on a number of fronts — in manufacturing, medical and atomic research, motion pictures and television — were spotlighted October 15 when more than 500 scientists met at Rochester, N. Y., for the 38th annual meeting of the Optical Society of America.

During the three-day meeting, a record number of 78 contributed papers were presented at the technical sessions held at the Dryden Theatre. Among the speakers were: Dr. George R. Harrison, dean of science at M.I.T.; Dr. Aden B. Meinel, associate director of Yerkes Observatory; Prof. M. A. Bouman from The Netherlands; Cmdr. Dean Farnsworth, U. S. Naval Medical Research Laboratory; Dr. Howard S. Coleman, Bausch & Lomb Optical Co.; Dr. Brian O'Brien, American Optical Co.; and Prof. Robert E. Hopkins, School of Optics, University of Rochester.

Other highlights were a symposium on current developments in the motion picture industry, a dinner meeting at the Sheraton Hotel with retiring president, Dr. O'Brien, the guest of honor and the awarding of the Frederick Ives Medal to Prof. Harrison M. Randall, University of Michigan, for outstanding research in infrared optics.

Ten Lectures on Color at University of Toronto

Is there a substitute for color taste? What is color blindness? What part does fashion play in color? These are some of the questions being answered at lectures now under way at the University of Toronto on "Color — Its Behavior and Application."

The weekly courses started October 14 and will continue each Wednesday evening through December 16. Classes are held at 8 p.m. in Room 252 of the Mechanical Building, King's College Rd., Toronto.

(Continued on page 26A)

(Continued from page 25A)

Standardization Seminars To Be Held in January

A five-day private seminar on industrial standardization will be given by Dr. John Gaillard, mechanical engineer on the staff of the American Standards Association, from January 25 through 29, 1954 at the Engineering Societies Building, 29 West 39th St., New York City.

The Gaillard seminars were started in 1947 to assist companies in organizing their standardization work and in training their men in writing standard specifications. The sessions this January will consist of ten conferences, morning and afternoon.

Further information may be obtained from Dr. Gaillard, 400 West 118th St., New York 27, or through the American Standards Association.

Advanced Conference Held At GE Lighting Institute

An advanced conference in Industrial and Commercial Lighting was held October 26-30 at the General Electric Institute, Nela Park. The conference was designed to be of particular interest to utility salesmen and engineers, architects, consulting engineers, interior designers, educators, industrial and maintenance engineers and all those who have had the equivalent of a lighting fundamentals course and wish more advanced instruction.

The full-day sessions, conducted by GE's lighting engineers, covered light sources, industrial lighting, office and school lighting, maintenance, store lighting, display lighting, home lighting, comfort rating systems and many other aspects of illuminating engineering. Group conferences on applied lighting covered the technical aspects of lighting developments on specialized subjects.

ABOUT PEOPLE

Dr. William D. Coolidge, former vice-president and director of research for General Electric, was honored October 20 on the occasion of his 80th birthday by more than 100 friends and associates. The celebration was held at Nela Park.

The appointment of **Dr. O. G. Haywood, Jr.** as Manager of Engineering Planning of Sylvania Electric Products, Inc., has been announced. In his new position Dr. Haywood will coordinate, in cooperation with executives of the operating divisions and research laboratories, Sylvania's engineering planning in the fields of lighting, radio, electronics and television, with particular emphasis on the long range future of company engineering.

Carl L. Powell has recently joined Day-Brite Lighting, Inc., as Director of Sales Training. His office will be in the general company headquarters at 5411 Bulwer Ave., St. Louis. For the past 13 years Mr. Powell has been with Graybar Electric Co., most recently as manager in Flint, Mich. A long time member of I.E.S., Mr. Powell has served on the Board of Managers of the Ohio Valley Section.

Rollo Gillespie Williams has been named Color Lighting Consultant with the Sales Engineering Division of Century Lighting, Inc. Mr. Williams will also be concerned with applications of lighting in theatres, television studios, display and architectural lighting.

Prescolite Manufacturing Corp., Berkeley, Calif., has added a complete manufacturing and sales division in Neshaminy, Pa., a suburb of Philadelphia. The new plant will service Atlantic seaboard electrical wholesalers. Initial operations in Neshaminy will employ about fifty plant personnel. The Neshaminy plant will be under the supervision of **Preston A. Jones,** one of the company's founders. **W. P. Epling,** formerly plant superintendent of the Berkeley plant, has been appointed Resident General Manager.

The American Society for Testing Materials has announced the appointment as Special Assistant, on the headquarters staff, of **Fred F. Van Atta.** Mr. Van Atta was recently manager, Building Division, Carolinas Branch, Associated General Contractors.

Charles W. Flood, Jr. has been appointed manager of miniature and automotive lamp sales for the Westinghouse Lamp Division, Bloomfield, N. J. In addition to his new job, Mr. Flood will continue to manage Christmas tree lamp sales and the division's licensing of its Tenderay operations. The new manager, who has been with Westinghouse since 1941, succeeds **Frank Paeske,** who expects to retire in the near future.

John S. Kinnaird has been named sales manager of the Leadlight Fixture Co., Oakland, Calif. At the same time it was announced that **Leonard Walker** will handle Northern California sales for the company and that **Fred Gleason** and **Don Gleason** have been appointed sales agents for the company in Oregon, Washington, Idaho, Montana and Alaska.

Arthur E. Rowe has been appointed manager of sales for the General Electric Co.'s newly formed Ballast Department. Mr. Rowe was formerly manager of lighting component sales for the company.

The Franklin Medal, highest honor awarded by the Franklin Institute, Philadelphia, will be awarded this year to **William Francis Gibbs,** naval architect and marine engineer, because of laborious efforts in the fields of naval engineering and architecture which ultimately led to the design of the vessel, the *S. S. United States.* Formal presentation of the award was made at the Institute's Medal Day ceremonies, Wednesday, October 21.

NEW MEMBERS

At the meeting of the I.E.S. Council held in New York, N. Y. on October 8, ship. Names marked * are transfers from Associate Member grade.

ALAMO CHAPTER

Associate Member:
Gilbert, P. O., Central Power & Light Co., Victoria, Texas.

ARIZONA CHAPTER

Associate Members:
Brown, A. W., 590 W. Pierson St., Phoenix, Ariz.
Hamby, A. E., Motorola Inc., Phoenix, Ariz.
Oates, J. H., New State Electric Co., Phoenix, Ariz.

BRITISH COLUMBIA SECTION

Member:
*Pettet, F. S., Western Lighting Fixture Co. Ltd., Vancouver, B. C.

CAPITAL SECTION

Associate Members:
Branch, J. O., Potomac Electric Power Co., Washington, D. C.
Chipman, R. B., Jr., General Electric Co., Richmond, Va.
Dulop, Stuart, Dunlop Lighting, Arlington, Va.
Walsh, D. A., Engineering Enterprises, Inc., Washington, D. C.
Withers, J. V., W. K. Trunnell, Inc., Bethesda, Md.

CAROLINAS SECTION

Member:
*Wilkinson, G. E., Mill Power Supply Co., Charlotte, N. C.
Associate Members:
Ashby, J G., Sylvania Electric Products, Inc., Raleigh, N. C.
Miller, P. E., Sardis Rd., Charlotte, N. C.
Wilson, A. A., Graybar Electric Co, Inc., Charlotte, N. C.

CENTRAL ILLINOIS CHAPTER

Associate Member:
Hovind, Robert, Caterpillar Tractor Co., Peoria, Ill.

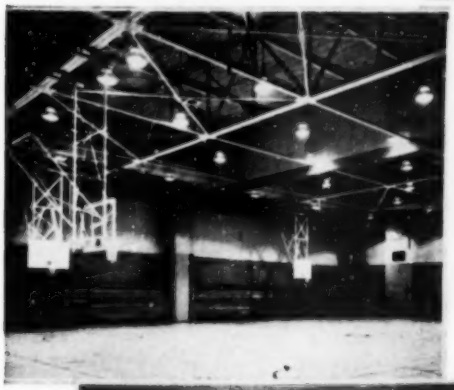
CENTRAL NEW YORK SECTION

Associate Member:
Fortunato, N. J., Fortunato Electric Co., Syracuse, N. Y.

(Continued on page 28A)

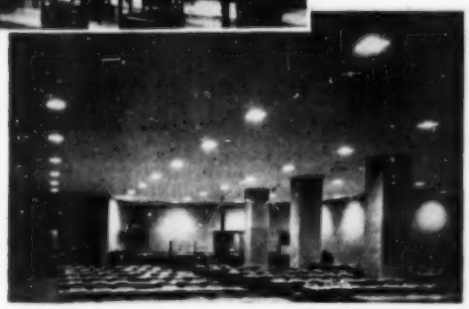
There's a Holophane Specific for effective lighting of

- Study Halls
- Kindergartens
- Administrative Offices
- Classrooms
- Work Shops
- Chapels
- Swimming Pools
- Laboratories
- Medical Rooms
- Auditoriums
- Corridors
- Gymnasiums
- Cafeterias
- Blackboards



Holophane Offers the Finest Lighting for Every School Area...

Since 1898 Holophane has consistently contributed to scholastic progress by providing the most efficient illumination for educational buildings . . . With this long experience, Holophane has pioneered in the development of lighting units specifically designed for each work or play area in the modern school or college . . . The Holophane Engineering staff offers qualified counsel, without obligation, on any educational lighting project.



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Write for this latest book . . . 56 pages of vital lighting data.

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I.E.S. Regional Conferences, 1954

Southern	Roosevelt Hotel New Orleans	April 8-9
Southwestern	Rice Hotel Houston	April 11-13
Inter-Mountain	Denver	April 15-16
South Pacific Coast	Museum of Art San Francisco	April 19-20
Pacific Northwest	Benjamin Franklin Hotel Seattle	April 22-23
Canadian	King Edward Hotel Toronto	April 28-30
Great Lakes	Sheraton-Cadillac Hotel Detroit	May 3-4
Northeastern	Hartford	Week of May 17 (one day)
Midwestern	Jefferson Hotel St. Louis	June 17-19

(Continued from page 26A)

CHICAGO SECTION

Associate Members:
Doner, W. G., Public Service Co., Maywood, Ill.
Knox, A. L., Garden City Plating & Mfg. Co., Chicago, Ill.
Meeker, J. S., Garden City Plating & Mfg. Co., Chicago, Ill.
Murphy, R. A., Potter Electric Shop, Kankakee, Ill.
Ross, G. W., Sylvania Electric Products, Inc., Chicago, Ill.
Sanders, Kerr, Jr., Chicago Lighting Institute, Chicago, Ill.
Smick, R. L., Macbeth Corp., Chicago, Ill.
Spitz, W. E., 410 S. Michigan Ave., Chicago, Ill.
Student Member:
Speltz, S. E., University of Illinois, Champaign, Ill.

CLEVELAND SECTION

Associate Members:
Porter, C. R., Western Reserve University, Cleveland, Ohio.
Ronayne, J. H., General Electric Co., Cleveland, Ohio.

CONNECTICUT SECTION

Member:
Ballard, R. E., Connecticut Light & Power Co., Hartford, Conn.
Associate Member:
Cramer, P. F., Jr., John P. Legnos Associates, Newington, Conn.

CORNHUSKER CHAPTER

Associate Members:
Maynard, D. J., 2401 S. 11th St., Lincoln, Nebr.
Stone, T. C., 3209 Myrtle St., Sioux City, Ia.

EASTERN PENNSYLVANIA SECTION

Associate Members:
Lefko, Harry, Westinghouse Electric Corp., Wilkes Barre, Pa.
Staudt, C. B., Pennsylvania Power & Light Co., Pottsville, Pa.
Weand, W. H., Sheets Electric, Pottsville, Pa.

FOREIGN NON SECTION

Associate Members:
Doughty, C. L., Bermuda Electric Light Co. Ltd., Hamilton, Bermuda.
Earle, R. A., Messrs. Veritys, Ltd., Bristol, England.
O'Mahony, J. F., 89 Ballymun Rd., Glasnevin, Dublin, Eire.
Ratcliffe, R. A., Simplex Electric Co., Ltd., London W.1, England.
Rotsmales A., Sergio, Empresa Constructora "Sigma," Santiago, Chile.
Smith, W. A., Australian White Lite Co. Pty. Ltd., Sydney, N.S.W., Australia.
Student Member:
Morales, Ricardo J., Apartado N. 2394, Caracas, Venezuela.

GEORGIA SECTION

Members:
Blakely, T. E., 8 11th St., N.E., Atlanta, Ga.
°Cantrell, W. T., Georgia Power Co., Macon, Ga.
°Haslam, T. W., Georgia Power Co., Atlanta, Ga.
Associate Member:
DuBose, E. R., White Electrical Construction Co., Atlanta, Ga.

HEART OF AMERICA SECTION

Member:
Vance, H. B., 113 E. Arrow, Marshall, Mo.

INDIANA SECTION

Members:
°Chellew, Z. M., Indianapolis Power & Light Co., Indianapolis, Ind.
Hetzel, R. J., Westinghouse Electric Corp., Indianapolis, Ind.
Associate Member:
Clevenger, R. A., Richmond Electric Co., Richmond, Ind.

INLAND EMPIRE CHAPTER

Associate Members:
Beadle, T. W., Washington Water Power Co., Spokane, Wash.
Ruffatto, John, Columbia Electric & Mfg. Co., Spokane, Wash.

MEXICO CHAPTER

Associate Members:
Lopez Zavala, Javier, Ciudad Universitaria, Pedregal de San Angel, Mexico, D. F.
Plasencia, Aurelio, Cables Armados Mexicanos, S. A., Coapa, Mexico, D. F.
Saldivar, Antonio, Instalaciones Electricas Souza S. A., Reforma #27, Mexico.

MICHIGAN SECTION

Associate Member:
Schalleau, B. A., 612 Cypress St., Manistee, Mich.

MILWAUKEE SECTION

Associate Member:
Rainey, J. G., R. 3, Sheboygan, Wis.

MONTREAL SECTION

Associate Members:
Bahr, J. N., Tru Lite Ltd., Montreal, Que.
Ford, Philip, Union Electric Supply Co., Ltd., Montreal, Que.
Paquette, Maurice, Union Electric Supply Co. Ltd., Montreal, Que.

NEW ENGLAND SECTION

Member:
Matheson, W. G., Sylvania Electric Products Inc., Salem, Mass.

NEW ORLEANS SECTION

Associate Members:
Corrigan, C. E., Jr., 504 Delta Bldg., New Orleans, La.
Parkerson, Emmet, Jr., Corrigan & Parkerson, New Orleans, La.
Stumpf, R. S., Westinghouse Electric Corp., New Orleans, La.

NEW YORK SECTION

Members:
Adams, A. G., 150 Baker Ave., Bergenfield, N. J.
Beagle, H. S., Electrical Testing Laboratories Inc., New York, N. Y.
Cyr, E. L., Dept. of Public Safety, Newark, N. J.
Greene, H. A., Edward F. Caldwell & Co. Inc., New York, N. Y.
°Grenadier, Lewis, Ender Monarch Corp., Westbury, L. I., N. Y.
°Levenstein, Jules, Ender Monarch Corp., Westbury, L. I., N. Y.
Margaretten, E. J., 60 Hudson St., New York, N. Y.
Associate Members:
Barber, L. C., International General Electric Co., New York, N. Y.
Cusumano, E. D., 5301 Palisade Ave., West New York, N. J.
Dussault, A. J., Sylvania Electric Products Inc., New York, N. Y.
Ernest, Herbert, Luminous Ceilings Inc., New York, N. Y.
Holzinger, J. R., 138 Sunnyside Blvd., Dumont, N. J.
Kolbe, G. K., Smitheraft Lighting Division, A. L. Smith Iron Works, New York, N. Y.
Little, C. T., Acme Electric Corp., New York, N. Y.
Thurkauf, Fred, Jr., Public Service Electric & Gas Co., Paterson, N. J.
Urdang, Laurence, Luminous Ceiling, Inc., New York, N. Y.
Whitley, A. F., Public Service Electric & Gas Co., Newark, N. J.
Yellen, Stuart, Benjamin Electrical Engineering Works, New York, N. Y.
Student Members:
D'Amelio, Joseph, Daniel Schwartzman, Architect, New York, N. Y.
Haft, L. J., Columbia University, New York, N. Y.

NORTHERN CALIFORNIA SECTION

Associate Members:
Andem, K. S., American Can Co, San Francisco, Calif.
Begovich, N. A., Fireman's Fund Insurance Co., San Francisco, Calif.
Lee, H. A., Pacific Gas & Electric Co., San Francisco, Calif.
Willmott, W. H., San Francisco Ltg. & Supply Co., San Francisco, Calif.
Wrathall, J. L., Westinghouse Electric Corp., San Francisco, Calif.

NORTHWESTERN OHIO CHAPTER

Member:
°Taylor, R. M., The Toledo Edison Co., Toledo, Ohio.
Associate Members:
Cloer, J. B., The Toledo Edison Co., Toledo, Ohio.
Smith, Thurley W., Artopoeus Sales Co., Toledo, Ohio.

OHIO VALLEY SECTION

Associate Member:
Gruber, H. J., Cincinnati Gas & Electric Co., Cincinnati, Ohio.

(Continued on page 39A)

DERBY DOWNLIGHTS—Endless applications. 7″ diameter recessing downlights, available with matt black removable louver or with Holophane Controlens*. UL approved.

DUO-FRAME UNITS—Recessing units with Holophane, Corning, and Phoenix glassware. Two-piece frame. Drop hinges. Vertical and horizontal lamp mounting units. UL approved.

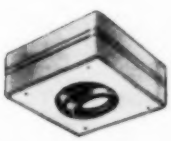
EXIT SIGNS—Surface, recessing, top and end mounting units. Metal stencil sign faces, backed by red glass. HOT-BONDED lustre aluminum finish. UL approved.

NITE LITE—One-piece, die-drawn recessing box. Louvered face with concealed hinge for easy servicing. Stainless steel or baked lustre aluminum finish. UL approved.

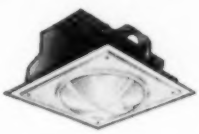
BED LAMP—Direct-indirect hospital unit. For three 50/60 watt lamps. Stainless steel finish. Controlens* panel in bottom, diffusing glass in top. UL approved.

PLEXOLINE® ACCENT UNITS—For use singly or with PLEXOLINE linear units. Adjustable and fixed units. Louvered body provides spill light on sides. UL approved.

TROFFER ACCENT UNITS—Self-contained square recessing units, adjustable or fixed, flange or snap-in type. May be used singly, within or at end of troffer runs. UL approved.



SURFACE MOUNTED ACCENT UNITS—Adjustable units or fixed units with Holophane Controlens*. May be used singly or with VIZ-AID® or LENOX® fixtures. UL approved.



RECESSING CORRIDOR UNITS—Available with two optical characteristics: asymmetric and symmetric. Flange or snap-in. Holophane* prismatic glass globe. UL approved.

* ® HOLOPHANE CO., INC.

A complete line of incandescent units by Day-Brite

When the name "Day-Brite" is mentioned, you think of the nation's finest line of fluorescent fixtures. This is to remind you that there's an equally fine line of Day-Brite incandescent units—giving you the advantages of Day-Brite quality and design for every piece of equipment called for in any type of lighting job. Write for full descriptive product information on the Day-Brite incandescent line. You'll find it a valuable addition to your files.

"DECIDEDLY BETTER"
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Lighting Fixtures

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A GREAT **NEW** LIGHTING DEVELOPMENT

by Eastern

4 DIFFERENT DISTRIBUTIONS IN ONE GREAT SERIES

10/90 20/80 30/70 40/60

A "CUSTOM MADE" LIGHTING RESULT FROM REGULAR STOCK UNITS

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FLUORESCENT & SLIMLINE IN 4, 6 & 8 FOOT UNITS

Eastern HEAVY DUTY "IN" SERIES INDUSTRIALS FEATURE:

- 86.5 efficiency louvered
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- 35% cross shielding
- No dark spots
- Simple low cost maintenance
- Dust free design
- Available in 3 louver cutoff
  35° X 25° 35° X 45° 45° X 45°

This extra heavy duty Industrial Unit allows you to offer your customers lighting that is virtually "custom made" to their individual requirements. The combination of 4 different distributions available in this one unit at no extra cost, plus advanced Eastern Engineering and Features make the IN Series the first real outstanding development in industrial lighting fixtures in years.

IN Series units are normally shipped with 40 up — 60 down distribution — other distributions should be specified when ordering.

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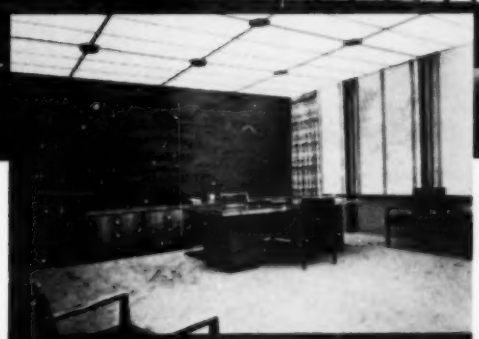
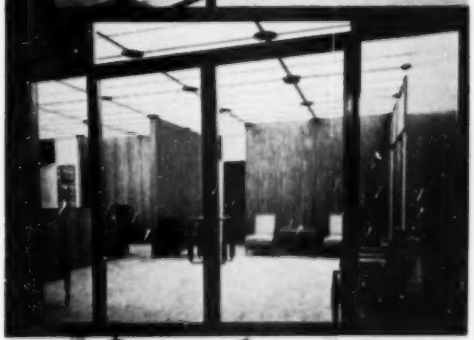
For Luminous Ceilings at Their Best—

PLEXIGLAS





Architects: Saarinen-Saarinen & Associates.

Canadian Distributor: *Crystal Glass & Plastics, Ltd., 130 Queen's Quay at Jarvis Street, Toronto, Ontario, Canada.*

PLEXIGLAS is listed in Sweet's Architectural File, Section 6d/Ro.

Luminous ceilings with diffusing panels of PLEXIGLAS® provide highest quality lighting and clean, fixture-free appearance in offices, lobbies and corridors of this Engineering Staff building of a major motor car manufacturer. In addition, they conceal air ducts, and water pipes for sprinkler heads located inconspicuously below the diffusers.

Luminous ceilings are at their best in function and appearance when the all-important diffusers are PLEXIGLAS, because this Rohm & Haas Company acrylic plastic:

. . . *provides efficient, uniform diffusion of light.*

. . . *resists discoloration and breakage.*

. . . *is strong, light in weight, and dimensionally stable.*

. . . *can be formed at low cost to custom shapes.*

. . .

We will be glad to send you literature on the use of PLEXIGLAS for luminous ceilings and large-area fixtures.

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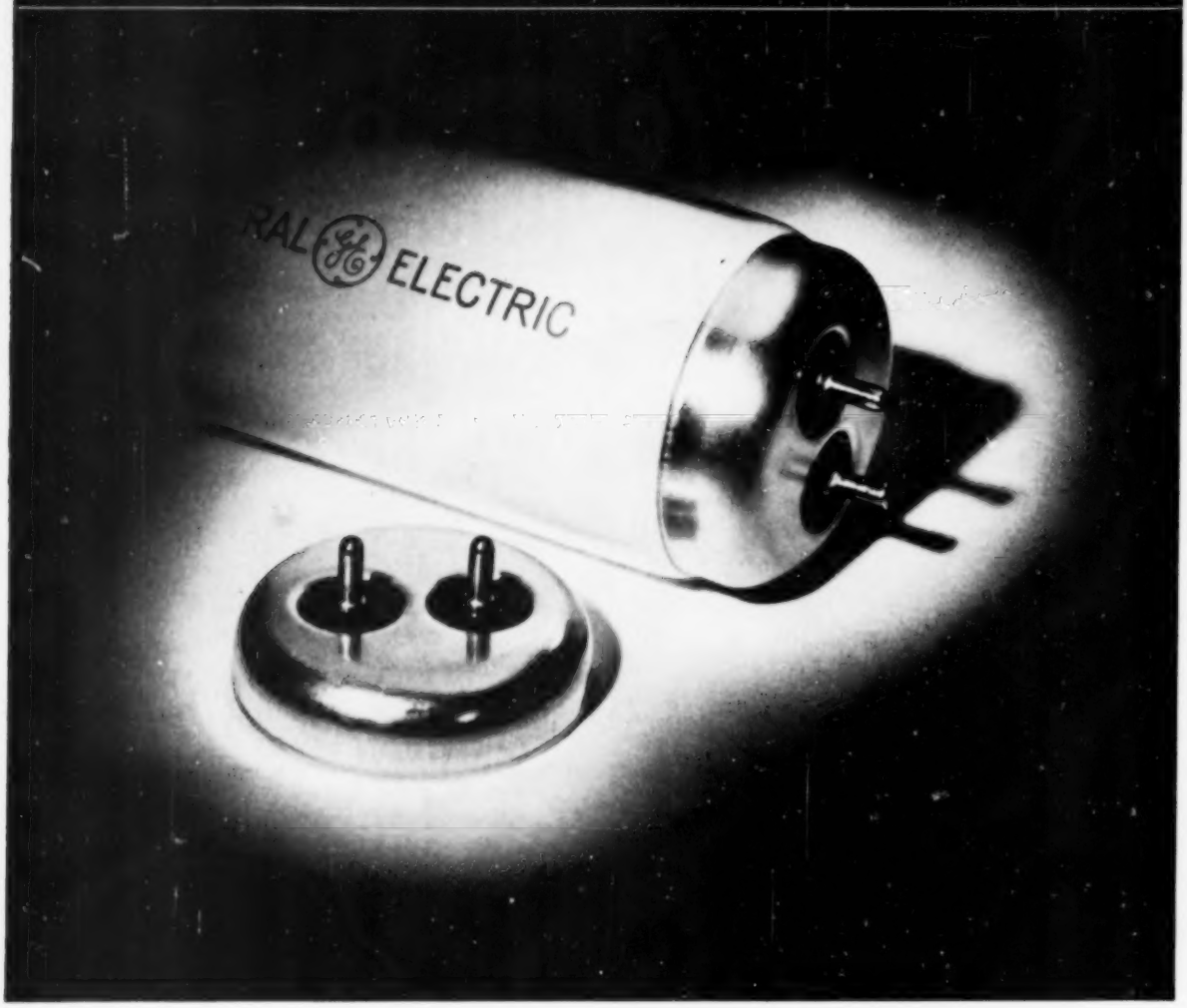
You expect the best value from G-E fluorescent lamps



Rugged aluminum base helps G-E lamps last longer

You've probably noticed that G-E fluorescent lamps now have bases made of a white shiny metal, instead of the usual yellow brass or black plastic. It's aluminum.

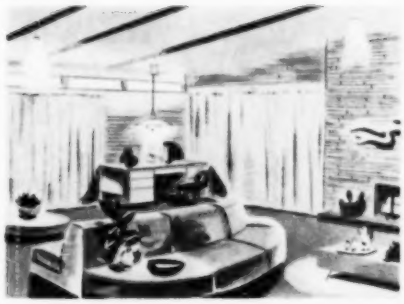
Aluminum is light and resilient. Won't crack from hard bumps and jolts. Can take the high heats needed to get the best seal between base and glass tube. Doesn't shrink at low temperatures, won't crack the glass tube in cold weather. It helps prevent failure in G-E lamps.

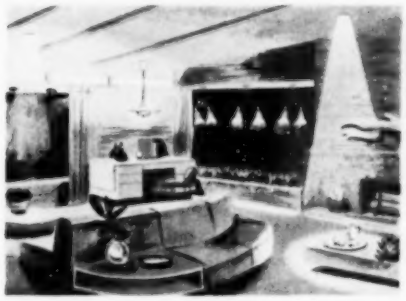
Five years of General Electric lamp research helped make this use of aluminum possible. It shows again why you can *expect* the best value from G-E fluorescent lamps.

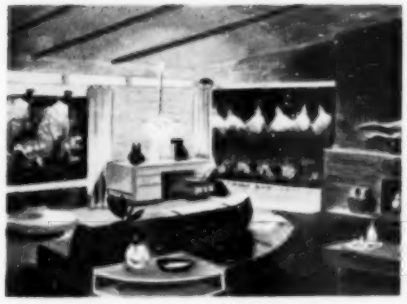
You can put your confidence in—

GENERAL ELECTRIC

Captures Client Imagination!







Inspiration-Lighting by MOE LIGHT

Inspiration-Lighting by MOE *Light* is a revolutionary new approach that enables you to make more dramatic layouts . . . that helps you to sell lighting effects, not merely lighting fixtures.

Peggy Clark, creator of fabulous lighting effects for many leading Broadway productions such as "Pal Joey," "Brigadoon," and "High Button Shoes," has adapted her ideas to home use . . . now tells how to "paint with light," create a mood, change the personality of a room—simply by flicking a light switch. MOE *Light* Contemporary, Traditional, Accent, Recessed and Wall Lighting work wonders in bringing out the full beauty of furniture, draperies and floor coverings, too.

WRITE FOR THIS HELPFUL LITERATURE

Contact your MOE *Light* distributor for a free MOE *Light* catalog. Better yet, send $1.00 for the sensational 48 page book, "YOUR HOME and *Inspiration-Lighting*." You'll find it a tremendously helpful sales-tool with page after page illustrated in rich full color . . . scene after scene of breathtaking ideas and suggestions for applying Peggy Clark's *Inspiration-Lighting* methods. This primer tells how to change the scene without changing the scenery.

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☐ Send me a free MOE *Light* Catalog.

☐ Send me your glamorous, new 48 page book, "Your Home and *Inspiration-Lighting*" for $1.00. If I am not completely satisfied with the numerous suggested room layouts and ideas for applying Peggy Clark's *Inspiration-Lighting*, I can return the book to MOE *Light* within 10 days for a full refund. (Available *only* from MOE *Light*, Inc., Ft. Atkinson.)

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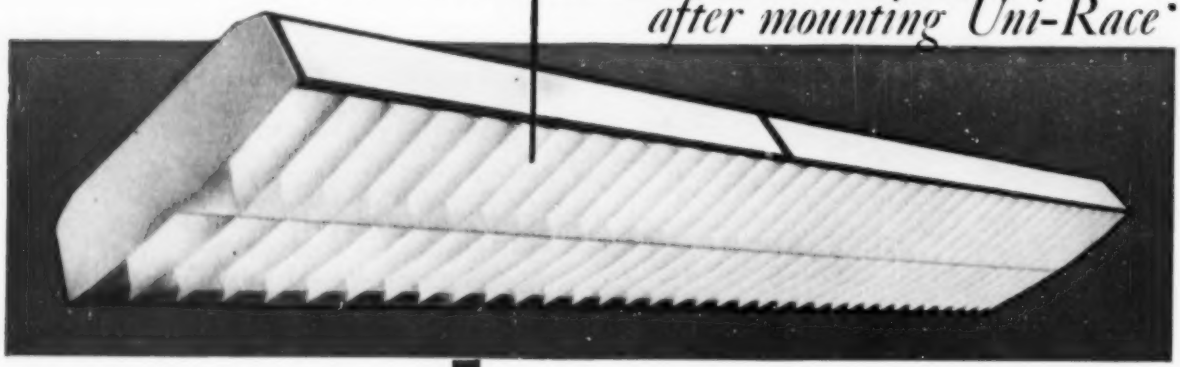
YOUR HANDS

are all you need to install the new Gibson

ortho-77
Reg U. S. Pat Off. · Applied For

after mounting Uni-Race



Patent Applied for

STEP 1: Mount UNI-RACE, a lightweight, rigid, open raceway.

STEP 2: Hang fixture into slots on UNI-RACE spaced for automatic positioning.

STEP 3: PLUG-IN socket makes contact with receptacle in Uni-Race when fixture is closed. Fixture is completely dead when open.

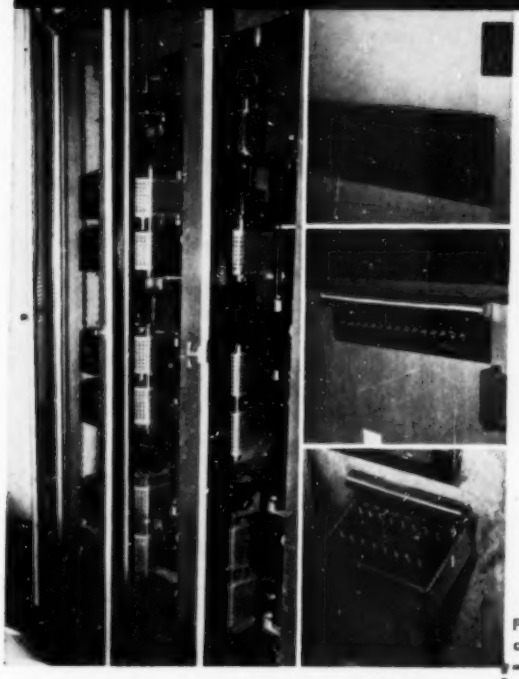
THERE IS NOTHING LIKE IT . . .

So revolutionary in design is the new Gibson ORTHO-77 it is the talk of lighting men everywhere. A special unique raceway (UNI-RACE) provides POSITIVE ALIGNMENT, AUTOMATIC SPACING, FIXED POWER SOURCE, and a RIGID CHANNEL ANCHOR for all ORTHO-77 models. Light in weight, it is readily accessible and easily mounted. A special receptacle permits wire-in in a matter of minutes without tools. Lighting levels can be raised from two to four lite on the same UNI-RACE, or fixtures mounted on a continuous UNI-RACE at spaced intervals can quickly be made continuous later. The fixture is never defaced . . . only the UNI-RACE, a low cost easily replaceable part. The ORTHO-77 is a completely INTEGRATED UNIT built around V-TYPE GIRDER CONSTRUCTION to assure rigidity and permanence of shape. These are just a few of the many features of this phenomenal new concept of design outlined in Bulletin ORT-101. By all means write for it today.

GIBSON *Manufacturing Co.*

1919 PIEDMONT CIRCLE, N. E. • ATLANTA, GEORGIA

powerstat light dimming equipment helps create a setting of reverence and devotion at SAINT SOPHIA CATHEDRAL, California



Architects: A. R. Walker
Gus Kalionzes

Electrical Engineer: H. F. Johnson
Electrical Contractors:
Pacific Electrical & Mechanical Co.

CONTROLLED LIGHT brings out the full beauty and richness of the traditional Byzantine interiors in the magnificent new Greek Orthodox Cathedral of Saint Sophia in Los Angeles. The Superior Electric Company is privileged that POWERSTAT light dimming equipment was selected to underscore the moving, centuries-old orthodox services.

The ultimate in light dimming equipment, the LUXTROL System, is employed to great advantage. Numerous miniature dimmer control panels are conveniently located in the cathedral with the motor-driven POWERSTAT Dimmers installed in an out-of-the-way space. Each selector station offers big switchboard operation in a compact, console-type control board.

Portion of the central POWERSTAT dimmer installation and several of the selector stations.

POWERSTAT LIGHT DIMMING EQUIPMENT
STABILINE AUTOMATIC VOLTAGE REGULATORS
5-WAY BINDING POSTS

THE SUPERIOR ELECTRIC CO.
BRISTOL, CONNECTICUT

VOLTBOX A-C POWER SUPPLIES
POWERSTAT VARIABLE TRANSFORMERS
VARICELL D-C POWER SUPPLIES

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Please send free literature on POWERSTAT Light Dimming Equipment.

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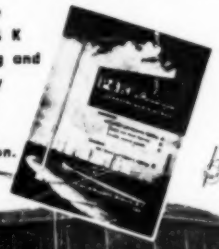

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(Continued from page 28A)

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(Continued on page 40A)

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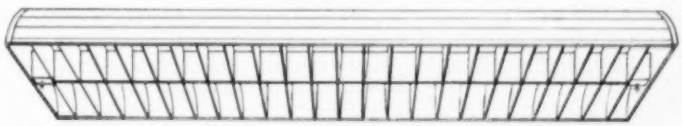

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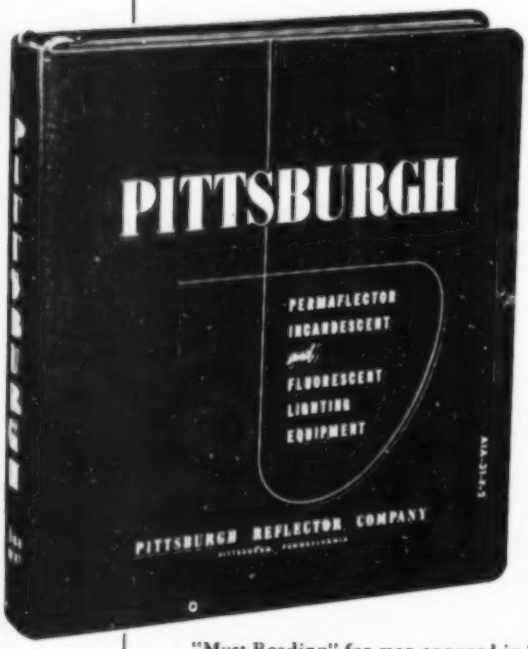

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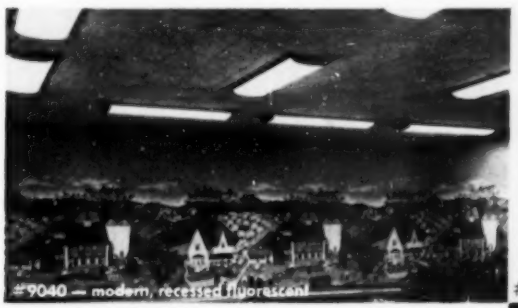

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RAPID-START LAMP MAKE	LIFE SPAN SUPERIORITY OF SOLA BALLASTED LAMPS
Brand "A" Lamp	46.7%
Brand "B" Lamp	14.7%
Brand "C" Lamp	9.7%
Average All Lamps	19%

19% more starts on rapid-start lamps with Sola Constant Wattage Ballasts

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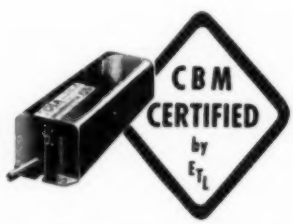

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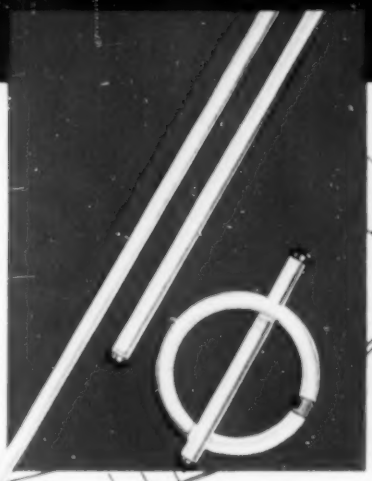

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LONG BALLAST LIFE — FREEDOM FROM OVERHEATING
QUIET, TROUBLE-FREE OPERATION

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